A Dissertation for the degree of Ph.D. in Geography

The Spatio-temporal Dynamics of Socio-economic Networks and Social Vulnerability Assessment for a Natural Disaster

- A case study of floods in Sri Lanka-

자연재해에 대한 사회경제적 네트워크의 시공간 역동성과 사회적 취약성 평가에 관한 연구: 스리랑카 홍수재해를 사례로

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The Spatio-temporal Dynamics of Socio-economic Networks and Social Vulnerability Assessment for a Natural Disaster

- A case study of floods in Sri Lanka-

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Abstract

This dissertation coupled together with the considering dominating ideas of socio-economic networks, related social capital and their influences on the ameliorating social vulnerability to flood inundation in rural and urban areas of Sri Lanka. Sri Lanka as a South Asian middle-income developing country has been experiencing adverse effects and consequences from torrential rains and related flood disasters since decades. In particular, in Sri Lankan society, strong socio-economic networks and reciprocal resource sharing and mobilizations, their collaborations, and altruistic nature of helping others (this is such a *de-facto* tradition) have affectively been forestalled the adverse effects and consequences of mass flooding events. On this context, this research seeks to examine the key research puzzle of 'What are the roles, efficacies and the Geographies of socio-economic networks and related social capital behaviors in the ameliorating social vulnerability to flood inundation in Sri Lankan soil?'

For the empirical study, 405 flood-inundated households were selected prior to their consent for household questionnaire survey covering 21 local administrative divisions (e.g. GNDs) in Sri Lanka. The study areas comprised 21 Grama Niladhari Divisions (GNDs) which are belonged to rural (15 GNDs covering 327 households) and urban (6 GNDs covering 78 households) geographical settings. For empirical data collection, household questionnaire survey, informal interviews, focus group discussions, and field observations were carried out during 13 months (from January, 2018 to January, 2019). The study mainly used Social Networks Analysis (SNA) methods, quantification of social vulnerability to flood inundation by applying Multi Facets Composite Social Vulnerability Index (MFCSVI), and some of qualitative methods in accordance with the mixed research method approach.

The empirical findings revealed that network characteristics and measures have changed over time (at before, during, and after phases) in different magnitudes and also observed evolutionary changes of network ties over time and among different geographical settings. In particular, related to all the rural GNDs, the key network measures (e.g. degree density, closeness, and betweenness centralities) are decreased from before flood inundation phase to during phase and then increased at after phase. On the contrary, in urban networks, those measures have increased from before phase to during phase and then decreased at the after phase. And also, network clusters are observed at both before and during phases similarly in rural and urban areas. Network structures are became more distributed forms at after phase in almost all the rural support networks. By contrast, all the structural changes of networks solely depend on the behaviors and characteristics of

reciprocal support ties and their resource mobilizations.

Social networks have been played a pivotal role in flood disaster responding at before, during, and after flooding events. Particularly, provision of information, food, water and other basic needs; evacuation and moving out belongings; provision of shelters; moving in belongings back; cleaning up contaminated households and public places; provisions of emotional and financial supports are strongly helped and mattered for securing and reviving flood-affected livelihoods. More importantly, major differences of support networks behaviors are observed in related to the urban-rural dichotomy and also among rural areas at lesser magnitudes. In other words, the regional support network behaviors in the flooding events are in stark contrast to the urban networks behaviors is diversified a plenty of ways. Much dense support ties are exemplified in rural areas compared to the urban contexts. Study also revealed that the villagers have very strong historical background of socio-economic networks and social capital in response to flooding events by the ways in which identified it as Traditional Social Capital (TSC) in this study.

The scores of social vulnerability to flood inundation are varied between sectors as well as within sectors. Kuruwita sampled households exemplified with fairly low scores of vulnerability compared to Elapatha and Colombo sampled households. For examples, in Kuruwita, Elapatha, and Colombo DSDs, the average vulnerability scores observed as 0.39 (with Min 0.01 and Max 0.875), 0.48 (with Min 0.113 and Max 0.996), and 0.56 (with Min 0.211 and Max 0.999) respectively. Regional diversities of vulnerability scores also are identified. Vulnerability mapping (household level and GND level) also revealed the different spatial patterns of social vulnerability distribution. Results show that MFCSVI is a suitable and sophisticated empirical application for regional level social vulnerability assessment in reference to the key vulnerability components.

Most notably, this study made some of contributions and theoretical implications to the existing body of literatures of related disciplines, for instances, analyzing of spatiotemporal dynamics of socio-economic networks of different flood-inundated geographical settings, the examining of the traditional social capital perspective of affected villages, and the empirical application of MFCSVI approach for social vulnerability quantification.

Keywords: Socio-economic Network Legacies, Geographies of socio-economic network dynamics, Social Capital, Reciprocal supports, Social Vulnerability to Flood Inundation, Traditional Social Capital (TSC), Flood disaster recovery.

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Abbreviations

HHs - Households

GND - Grama Niladari Division

DSD - District Secretariat Division

GNO - Grama Niladari Officer

DMC - Disaster Management Center

PAR - Pressure and Release Model

SoVI® - Social Vulnerability Index

IPCC - Intergovernmental Panel on Climate Change

ESAC - Exposure, Sensitivity, Adaptive Capacity

TSC - Traditional Social Capital

MFCSVI - Multi Facets Composite Social Vulnerability Index

Chapter 1. Introduction

1.1. Background and research problem

Natural disasters have adversely been becoming recognized at alarming level as their consequences on human societies are being augmented by many folds[1]. The severity of natural events such as extreme floods, landslides, droughts, earthquakes has increased not only in the developed world but also in the developing countries[2] throughout the worlds. Among these events, the flood disasters are becoming more onerous (e.g. McMaster and Baber, 2012; Ceddia, *et al*., 2017; Liu, *et al*., 2018; McGrath, *et al*., 2019; Li, *et al., 2019* etc.), as the phenomenon has tightly correlated with the rapid population growth particularly in the developing world. In this context, the social vulnerability of nations to extreme flooding events has been augmented with inextricable and deleterious impacts. Therefore, for example, Adger (2006), the foremost need of the world is that readying and changing resilient for sustaining life, their well-being, and the environment in order to adapt forthcoming potential extreme encounters. As the developing world is yet experiencing of lacking of sufficient capitals assets for the ameliorating social vulnerability to natural disasters, improving and building of social capital and mobilization of social goods is one of the preeminent ways to secure the vulnerable livelihood. For instance, the United Nations (2017b), points that the social goods (e.g. trust, solidarity, helpfulness, friendliness and hospitality) may be non-financial core asset for achieving the sustainable development goals (SDGs). The foremost advantage of this capital is its prowess in the disaster mitigation[3]. Conceptually, the social capital has closely intertwined with the socio-economic networks. By contrast socio-economic networks play a seminal role in building social capital, particularly in the disaster mitigation contexts (Adger, 2003; Zakour and Gillespie,

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[1] For example, Burton, Kates, and White (1993, P.249) the environmental threats have been becoming alarming level with rapidly increasing frequency. After 24 years of this publication, their guesstimates have been realized.

[2] For instance, with the mass increasing of natural hazards surges, the loss of property and life have exponentially been augmenting particularly in the developing world amid a range of human efforts to live in terms of collaborate and harmonious manner (Burton, Kates, and White, 1993, P.1).

[3] For instance, Zakour and Gillespie (2013, P.23) an existence of social capital is identified as viable environmental related capability. For the disaster recovery and emergency management, social support is one of the instrumental social capital types. Often, social supports have been acting as a buffer in order to mollify the massive consequences of natural disasters on human lives and their livelihood.

2013, P.117). Of course, for example, Baird and Gray (2014), particularly in rural areas, in the developing world, socio-economic networks and their reciprocal activities are significant components for securing lives and their livelihoods, mitigating and reducing adverse effects of disasters, and improving social wellbeing. According to personal experiences, especially rural areas in the Sri Lankan soil, a range of helping flows / reciprocal supports (foods, water, goods, healthcare facilities, sheltering, emotional and financial helps and other basic needs etc.) can be seen in the disaster events which can be identified as *de facto* altruistic traditions of helping each other in terms of reviving and resurrecting affected livelihoods. This study will be examined the prowess of socio-economic networks, their geographical diversities, in the ameliorating social vulnerability to flood inundation, in Sri Lanka.

Taking into accounts to the key theme, vulnerability studies have been becoming one of the key themes in the contemporary scientific research this is because the numbers of people who are vulnerable, in particular to natural hazards have adversely been augmented within last few decades. The crucial hinge of this phenomenon is the mass of victims is belonged to the developing nations. Thus, the vulnerability to disasters has been evolving as an inextricable trap or impasse in developing countries. By contrast, in the developing world, especially rural and related to the informal settlements such as shanties and slums of emerging urban cities, the issues of land entitlements and resourcefulness are closely associated with the vulnerable to disasters[4]. This situation has been becoming worse with the rapid expansion of population particularly in global south (United Nations, 2017).

Jedwab and colleagues (2017), point that developing countries have urbanized rapidly since 1950. With this rapid expansion of urban population, unplanned and informal settlements also have been growing at alarming level in urban cities (Potts, 2011; Van Gelder, 2013; Wurm, *et al.,* 2017). Within this circumstance, the dilemma of vulnerability to natural disasters in urban cities has also been become more onerous particularly in the developing world (Wang, *et al.*, 2008; Al-Nammari, and Alzaghal, 2015; Wang and Taylor, 2016; Rowe, *et al.,* 2017). South Asian developing countries also have been exemplified for a spectrum of natural hazards at similar frequent or more than to other developing nations (Heltberg, 2007; Gautam, 2012; Li, *et al.,* 2015; Nath, *et al.*,2017; Vinke, *et al.*, 2017).

Flooding events are the most crucial among natural disasters in terms of

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[4] Rakodi (2002, P.14), for example, *"the assets which poor people possess or have access to, the livelihoods they desire and the strategies they adopt are influenced by the context within which they live. This is conceptualized as having two broad dimensions: factors that influence their vulnerability, and policies, institutions and processes"*.

vulnerability to flood hazards particularly in the South Asian countries (e.g. Mirza, 2011; Kale, 2012; Kale, 2014; Abbas, *et al.,* 2016; Talukdar and Pal, 2017; Misra, *et al.*, 2017). In the South Asian region, Sri Lanka is as an island country which can be identified as one of adversely affected countries mainly by flood and also by droughts, tsunamis, cyclones, coastal erosion, sea level rise, and landslides events (Wagenaar, *et al*., 2019; Nandalal, 2009; Lo and Koralegedara, 2015; Eriyagama, *et al.*, 2017; Farley, *et al.,* 2017). One of the major flooding events in Sri Lanka which was by Tsunami, for example, (Wijetunge, 2006) that's on 26th of December, 2004, 13 out of the 14 districts belonging to the coastal belt were affected. And also, the reported deaths amount was nearly 40,000 with 15,000 injured and about 89,000 housing units either completely or partially damaged leaving one million people homeless and causing massive disruption to livelihoods. Moreover, according to Pelling (2003, P. 24), coastal cities which are located South Asia, Southeast Asia, the Caribbean, East Africa and Central America are more vulnerable for hurricanes and typhoons.

The city of Colombo is also a coastal city as its west boundary lying along the southwest coast of Sri Lanka. The causative factors for flooding in the city may beyond from the hurricanes and typhoons. One of the main rivers called Kelani river is flowing through the city and some of places of the city have mainly been flooding during Southwest monsoon period. For instance, according to the ministry of disaster management (2017), major floods in Sri Lanka which are associated with the two major monsoons. Typically, during the Southwest monsoon season (May to September) the Western, Southern and Sabaragamuwa provinces are vulnerable to floods (the city of Colombo is located in the western province and the rest of study areas namely Kuruwita and Elapatha DSDs are located in Sabaragamuwa province). During the Northeast monsoon (December to February) the eastern, northern and north-central provinces are prone to flooding. In recent years many flooding events had been occurred as the results of unprecedented torrential rainfall events particularly areas in the wet-zone of the country including Kuruwita and Elapatha DSDs and also the city of Colombo[5].

In this context, the city of Colombo has also been experienced adverse flooding

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[5] For instance, The New York Times (2017) reported that *"the state-run Disaster Management Center on Sunday announced that 151 people had been killed and 112 others were missing. It said the flooding was the worst since torrential rains soaked the island nation in 2003. The authorities estimate that more than 1,800 homes have been damaged and 442,000 people affected"*. According to the CNN (2017), *"Sri Lanka remains in the grips of the worst flooding in 14 years, and the bad weather that has killed at least 194 people is expected to continue, the Red Cross said Monday"*. BBC (2017) also points that *"at least 164 people have been killed and nearly 500,000 displaced in the flooding and mudslides triggered by heavy rains on Friday"*.

effects resulting irreparable lost in terms of human and physical[6]. According to the ministry of disaster management (2017), during thirty years period in Sri Lanka (1974 - 2004), number of people affected by natural disasters such as floods, drought, tsunami, storm and landslides have adversely been increased (figure1.1). Among these figures, flooding can be identified as the most hazardous event in Sri Lanka. Figure 1.2 illustrates the depth of inundation, and duration of floods in all study areas (Kuruwita, Elapatha, and Colombo, DSDs).

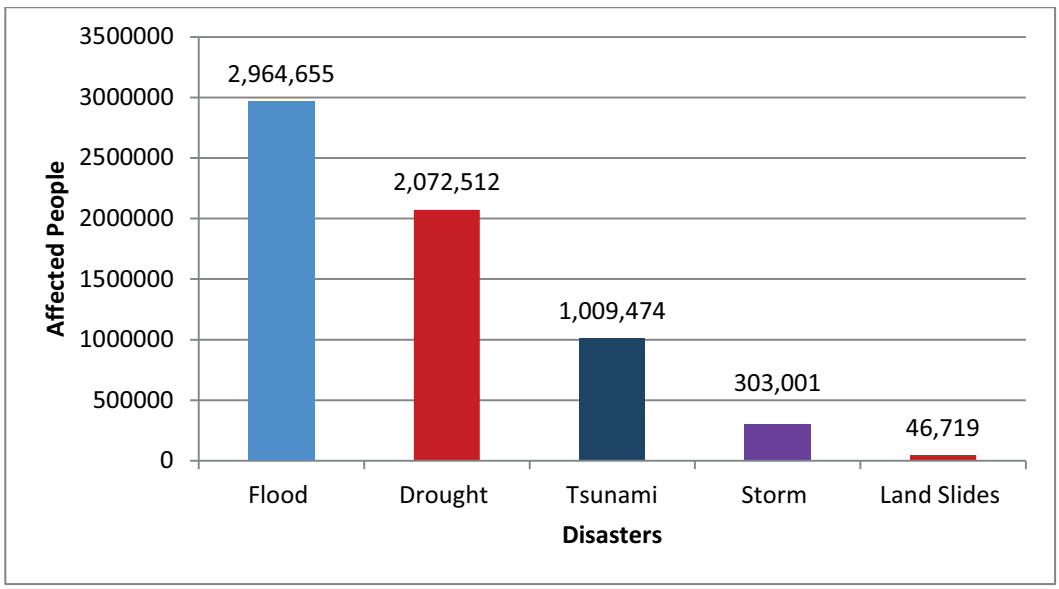

Figure1.1: Affected people by disasters from 1974 to 2004.
Source: Ministry of Disaster Management (2017).

At the beginning of June, 2017, the disaster management center (DMC, 2017), revealed that 70, 000 people are identified as severely affected by floods while 495, 000 people are identified as moderately affected. In accordance with the facts that examined, in every year, since the activation of South-west monsoon, many of places in the city of Colombo have been experiencing extreme flooding could profoundly impact urban livelihood. Eriyagama and colleagues (2017) for example,

[6] For examples, Gehrels (2016), points that *"the Colombo, the capital of Sri Lanka, was hit in May 2016 by the worst flooding since 1989. Combined with neap tide this led to the most devastating flood in almost three decades. In Colombo district alone, 185,000 people were directly affected by the floods"*. The Straitstimes (2016), accounts that *"the water levels in the capital Colombo are slowly receding after the Kelani river, which runs through the city of 650,000, burst its banks early last week. A massive cleanup is currently under way. However, many of the estimated 100,000 residents still sheltering in schools and other relief centers in Colombo say they have lost everything, and are unsure how to rebuild, Agence France-Presse reported"*.

emphasized that the flood frequency of wet-zone catchment has been an increased in recent years. *"It is commonly perceived that this increase is caused by a rise in the frequency and severity of 'very wet' precipitation events"*. They also urged that land-use change may be the main causative factor behind flood surges[7]. All study areas (Colombo, Kuruwita, and Elapatha DSDs) are belonged to the wet-zone of Sri Lanka. The situation has been becoming more onerous particularly in urban and suburb areas with the rapid urbanization and expansion of urban population[8]. Also, this is very clear according to the department of census and statistics (2015) data. For instance, within the years of 1881 and 2012, the urban population of the country has been increased from 281,065 (10.2%) to 3,704,470 (18.2%) respectively.

For Rakodi (2002, P.24), in South Asian countries, poverty appeared to be the major issue as developing nations. By contrast, poverty also may be one of the crucial elements among the urban people particularly who are living in the informal urban settlements[9]. Despite the fact that, according to the latest data revealed by the department of census and statistics (2015b), Colombo and neighboring Gampaha districts represent the lowest poverty headcount index (2012/13), 1.4% and 2.1% respectively compared to the rest of administrative districts of the country. The same report points that 31,456 people are identified as the estimated number of poor population in Colombo district. For CMC (2002), it was estimated that around 1,506 urban poor settlements were located within the CMC area as in 1998/99. These figures exemplified the credible evidence for the dissimilarities of income distribution. The poverty can be identified as one of the main vulnerability exponents in the vulnerability to natural disaster studies. World Bank (2016) also stressed that *"while urbanization has brought a high level of growth and development to Sri Lanka's cities, almost 50% of the poorest 40% of the country's population live within 30kms of urban areas. As a result, Colombo, the largest city, is also home to the greatest number of poor and vulnerable people"*.

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[7] For Gehrels (2016), regarding the increasing intensity of urban flooding, main reason are may be land filling of wetland system, informal settlements, clogging of city drainage systems etc.

[8] For instance, World Bank (2017) emphasized that Sri Lanka has been becoming one of rapidly and dynamically urbanizing countries in South Asian region. This mechanism proves by recent satellite images with nighttime lights mainly in nearby areas of Colombo city /peripheries where for example, transport arteries from city towards Kandy and Galle.

[9] For example, Colombo Municipal Council (CMC, 2002) points that the central parts of Colombo city comprise with majority of slums and shanties (e.g. squatter settlements) have been spreading along reservations of canals, reservations of railway lines and low-lying swampy areas where appeared mostly in eastern and southern sites of city.

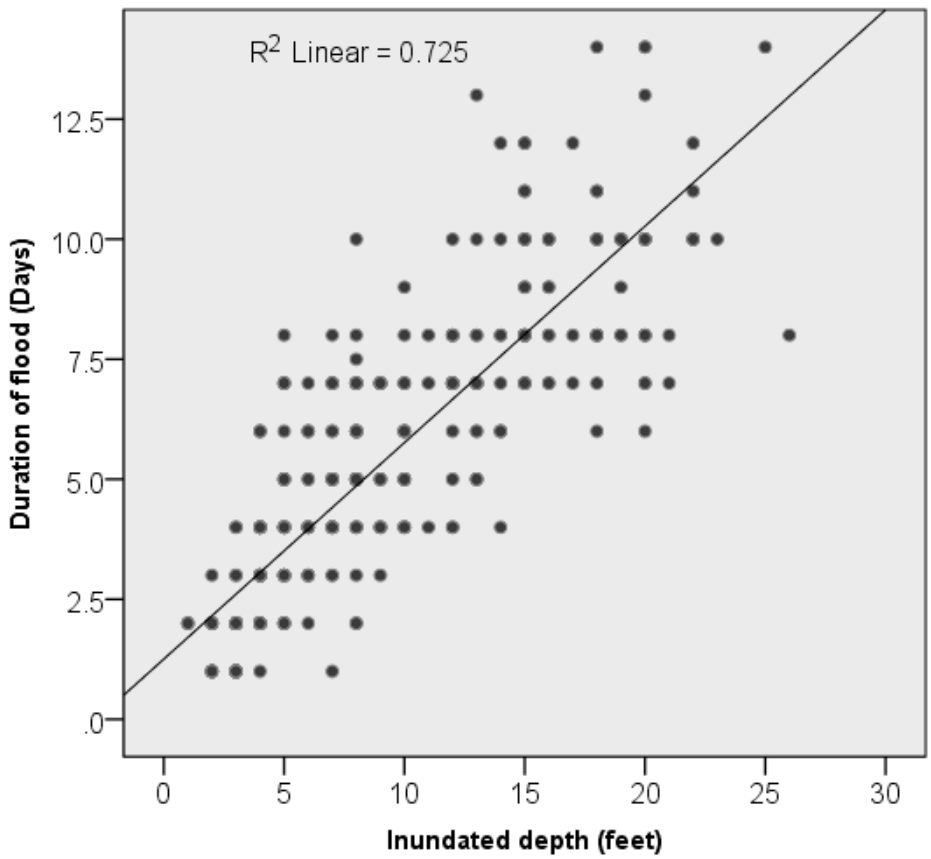

Figure 1.2: Inundation depths and duration of floods of surveyed households (some of observation units have overlapped which are represented with similar records). Source: Own Household Survey, 2018/2019.

In this context, socio-economic networks may play a seminal role in terms of securing and revivifying livelihoods while heightening the coping capacity against the devastative events. This study will sheds some lights on social vulnerability to flood inundation analysis combining the key research areas of social vulnerability and socio-economic networks. According to Zakour and Gillespie (2013, P.117), *"..the application of network analysis to vulnerability theory has been quite recent and limited. Nevertheless, network methods are well suited to address several of the general assumptions underlying vulnerability theory. We expect vulnerability researchers in the future to make increasing use of network methods"*. Their insight hints that the lacking of research applications of social networks on vulnerability analysis. In this context, socio-economic networks may have much credence in

terms of building coping capacity in the vulnerable livelihoods[10]. On the other hand, Waters and Adger (2017), their study on the adaptive capacity of urban poor, reveals specific determinants of adaptive capacity, pointing towards the importance of considering socio-cognitive factors, and different types of social support networks. In this end, social networks are very significant to reduce the adverse consequences of natural events like flood-inundation. Munasinghe (2007) emphasized that both the poor and rich are prone to disasters strike and the poor are solely depend upon such 'traditional, informal mutual-help networks' which is one of instrumental metaphors for them to fall back. However, richer' need solely depend on many things like mechanical devices, abundant electricity, food, water and services and impossible them to cope without that resources. Their lack of traditional knowledge also played a part. This idea represents an important dimension of social networks of poor people on ameliorating the social vulnerability. Also, it may important inference to investigate that the nature of social networks of rich people and potential linkages with the poor people whose both are under vulnerable to risk category but distinct groups. Of course, within group there may be some of analogous patterns. Zakour and Gillespie (2013, P.118) urge that networks influence on the severity of vulnerability in communities with greater magnitude. Moreover, according to Faas and Jones (2017), social networks work well in disaster management and mitigation by a plenty of ways, such as provision of helps, reciprocity, material, information, emotional and other many supports. Therefore, socio-economic networks may have potential and candid effects on vulnerable livelihood in the matter of mollifying vulnerability.

The research problem of this study has been knitted and formulated based upon above background which with related to adverse flooding events on rural as well as urban contexts. According to my personal experiences in Sri Lankan context, the social collaboration and supportive ties are very crucial not only in the disaster situations but also for managing in the day today life. In particular, regarding the disaster events (particularly before, during and after) many support flows (foods, goods, evacuations, sheltering, other basic needs, event educational material supports for schools) have effectively been mobilizing. These all are public donations and have been made tremendous effects in the livelihood revivifying and building. The reduction of social vulnerability to flood inundation via the exponent of socio-economic networks and related social capital is crucial as a 'disaster

[10] Thus, for example, Leenders and Gabbay (1999), the important aspect of social networks is that their abilities to provide privileged resources for actors in terms of lower transaction cots which make positive impacts on them.

mitigation'[11] metaphor in which became very urgent need in the developing world. The study areas of this research are Kuruwita, Elapatha and Colombo DSDs and those regions also almost belonged to the Bogardi's context. On the one hand, Kuruwita and Elapatha DSDs have a plenty of poor people who are living with a range of economic hardships and environmental stresses. On the other hand, in rural regions, they have been practiced kinds of instrumental traditional awareness mechanisms on the flood risks and almost all of them have intertwined with their social ties. In this context, building interrelationships with neighbors and also particularly with institutional bodies are needed in terms of strengthening the resilience and coping capacity of livelihoods.

Accordingly, my main argument is knitted as below. I considered, Professor Neil Adger[12] and his colleagues' ideas for formulating my research problem. Thus I build my core research puzzle based upon considering the following ideas as the slogan of my argument. *"the vulnerability of traditional societies will vary, however, according to their past experience with extreme events and flooding and the degree of social cohesion that is preserved in these communities. Some traditional societies have developed networks for support and reciprocity that are more effective than the natural disaster programs of even in the wealthiest countries"* (Turner, Subak, and Adger, 1999). Also, *"our study suggests that successful adaptation to multiple every day and infrequent shocks in urban informal settlements occurs in place and most often involves social support networks"* (Waters and Adger, 2017). Moreover, a spectrum of advantages such as social media supports, online socio-economic networks supports are crucial for emergency services and also in the healthcare facility provisions, resource sharing and access for privileged resources, knowledge sharing etc. Therefore, socio-economic networks are significant in a plenty of ways and it has become a necessity in the societies, in particular managing difficult situations and unexpected encounters. (e.g. Kim and Hastak, 2018; Kryvasheyeu, *et al*., 2015; Perkins, Subramanian, and Christakis, 2015; Leenders and Gabbay, 1999, P.3; Cronin, 2006, P.138). Similarly network-related social capital metaphor is also instrumental in disaster response and recovery (e.g. Jones and Faas, 2017). This is because, damaging social ties, improving distrust or untrusted feelings and overall breaking down of social ties may adversely effect to the community collaborations (e.g.

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[11] Bogardi (2006, P1), explains the worthiness of mitigation in the severity of disasters.

[12] Who is the ISI Highly Cited Researcher in the Social Sciences in the years 2015, 2016 and 2017, one of the few geographers whose work is widely cited across the disciplines (Retrieved from: http://geography .exeter .ac. uk/ staff /index.php?web_id=Neil_Adger, accessed: 31/02/2019).

Brass and Labianca, 1999, P.328; Kita, 2017). According to, Walker-Springett and colleagues' (2017) findings, quantitative and qualitative data revealed the important of social capital and social relations in mitigating the adverse effects to wellbeing by flood disasters.

Since Sri Lanka has been categorized as a high human development country, particularly country's literacy rate is very close to 100 and mean years of schooling also higher than some of very high human development countries like Singapore, Iceland, Italy, Greece etc. (Karunarathne and Andriesse, 2018; United Nations, 2016). In addition, communication facilities are also becoming advance with the state-of-the-art technologies even among rural communities. In that context, "the core puzzle" of this study is "What are the roles, efficacies, and Geographies of socio-economic networks (mainly) and related social capital behaviors in the ameliorating social vulnerability to flood inundation in Sri Lankan soil?" And also, "What are the characteristics and spatial patterns of social vulnerability to flood inundation particularly among socially variegated geographical settings and the urban-rural contexts?" My research is solely based upon abovementioned research puzzles. Generally, socio-economic networks can be identified as a part of social capital and in some circumstances they act as complimentary components in the disaster response and recovery. Especially, in the Sri Lankan society, it is very common and also a *de facto* tradition that people are being intertwined with their neighbors and relatives in particular, a range of relations are interlaced with cultural practices, norms, rituals and customs and shared values etc.[13]. Also, isolated individuals and groups or clusters are possible. Especially, abovementioned traditional ethos has been eroded or diminishing in the contemporary urbanized societies in Sri Lanka. In general, socially collaboration legacies have many abilities in terms of absorption of any kind of shocks and perturbations in which they meet. On this context, this study demonstrates the legacies of socio-economic networks and related social capital in the ameliorating social vulnerability to flood inundation. Figure 1.3 exemplifies the overall framework of the study as a glance.

1.2. Research questions and objectives

According to the above-examined background, the foremost and ultimate aim and purpose of this study is to emic understanding of the efficacy, geographies and crucial characteristics of socio-economic networks in the context of ameliorating

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[13] This is because, *"social networks have been a pervasive feature of Asian societies in general"* (Pennings and Lee, 1999, P.54).

social vulnerability to flood inundation. In the existing body of literature (which has reviewed here), there are limited scholarly works possible to be identified on above context. In particular, analyzing of the role of socio-economic networks in the context of social vulnerability to flood inundation is pivotal. In this context, following four main research questions are addressed;

i. How do socio-economic networks and related social capital react/matter in the flood inundation events (before, during, and after) and what are the role, geographies and efficacy of socio-economic networks for ameliorating social vulnerability to flood inundation?

ii. What are the status and characteristics of social vulnerability to flood inundation and how do those vary over different geographical settings and urban-rural dichotomy?

iii. What are the socio-economic network dynamics over time and spatial patterns of social vulnerability to flood inundation over rural-urban areas and how can be mapped the dispersion of them?

iv. How do socio-economic network characteristics differ over regional contexts and urban-rural areas in terms of ameliorating social vulnerability to flood inundation?

These research questions are very crucial as they are looking for appropriate methodological approaches in order to find significant solutions[14]. In accordance with the research questions, following two main objectives are formulated with two sub (specific) objectives to be investigated by this research work as follows;

i. To examine the role, efficacy and the geographies of socio-economic networks and related social capital at before, during, and after the flooding events in the ameliorating social vulnerability to flood inundation.

ii. To assess the nature and characteristics of social vulnerability to flood inundation in study areas.

[14] "*It is widely acknowledged by scholars across disciplines that research questions drive research methods. Contemporary research questions are more complex than ever, requiring complex methods for finding answers*" (Tashakkori and Teddlie, 2009, P.283).

a. To map the dynamic evolution of socio-economic networks over time and spatial distribution patterns of social vulnerability to flood inundation in rural and urban areas.

b. To examine the regional differences and rural-urban dichotomy of socio-economic networks at the flooding inundation events (before, during, and after) in reducing the implications of vulnerability.

1.3. Relevance and significance

Regarding the disaster situations, in particular, flooding events of Sri Lanka, a plethora of social support and subsidy flows can be seen in terms of flood disaster response, recovery and livelihood reviving. These all are "support flows" by means of mobilizing through socio-economic networks. And also, the supportive efforts (evacuation, foods, water and all the basic needs, financial and emotional supports etc.) have been done by publics, Buddhist temples, TV channels, community organizations, supportive organizations etc. More importantly, in particular, rural areas have very strong traditional base of socio-economic networks and related social capital (Karunarathne and Lee, 2019). These socio-economic supports are very crucial and very efficient in the urban-rural resilience building this is because disaster prevention, reduction of risk and consequences are comprehensively highlighted by global bodies like United Nations (2017). Despite, yet, none of studies have been investigated these reciprocal support flows and their values and influences in the ameliorating social vulnerability, particularly in Sri Lankan context. Very few fairly related studies found, for examples, on flood disaster resilience in the war-affected areas (e.g. Jayawardana, *et al.*, 2019); on assessment of flood adaptation (Wagenaar, *et al.*, 2019); on tsunami-based livelihood recovery and social capital (e.g. Minamoto, 2010); and world bank working paper on vulnerability and flood respond in Colombo (e.g. Patankar, 2017) in Sri Lankan context. However, those studies have not engaged with the socio-economic networks and social vulnerability analysis. And also, a few of studies can be seen in the global context (Misra, *et al.*, 2017; Htein, *et al.,* 2018; Stewart, *et al.,* 2014 etc.). This study bridges above particular gap in the existing body of literature by demonstrating the prowess of socio-economic networks and related social capital by means of analyzing their spatiotemporal patterns, rural-urban dichotomies in flood inundation events (before, during, and after) and how those related to the social vulnerability discourses.

In particular, regarding the rural context some flood-affected remote and countryside areas (especially many villages located in Elapatha DSD, some others

in Kuruwita DSD) have still been experiencing massive unemployment rates, poverty and also lacks of infrastructure facilities (own households survey, 2018/2019). Every year they have been experiencing and undergo with flood inundations. The devastating flooding events make by unexpected encounters have been increasing due to rapid climatic changes and these events adversely affect to the global south as those nations yet struggling with a plenty of economic hardships (IPCC, 2014). Therefore, we can postulate that the poor rural areas yet to be experienced serious consequences by those climatic events and also those consequences worse by many folds due to their living conditions. Therefore, this study make significant inference to the government policy considerations and regional planning endeavors by investigating the abilities of socio-economic networks in mollifying the adverse effects of flood inundation events and network potentials and their gaining momentums. Similarly, urban cities especially coastal city like Colombo. According to weather propensities[15], the identification of spatiality of the livelihood of vulnerability to flood inundation may play a seminal role in the urban development trajectories. By contrast, these areas warrant that immediate and effective prevention strategies from the authorities' end. These strategies will help to conquer the impediments of livelihood development and preservation by all the means. In addition to secure them from the possible future extreme climatic events is pivotal important. Also, the important of the city of Colombo as the strategic contributor to the economy has been advanced in plenty of ways. By contrast, collective spectrums of income sources are being clustered in the city of Colombo. In this context, present study will be significance in two folds. On the one hand, the investigations will be benefitted for the establishments of further mitigation measures for both rural and urban areas. On the other hand, it will be crucial for the policy implementation at ground level in rural as well as urban areas on vulnerable livelihood.

More importantly, *"Yet, the DMC (Disaster Management Centre) has consistently failed to inform vulnerable communities about the potential dangers posed by such disasters beforehand. Lack of prior planning and communication has been the main reason for the failure to avoid devastating effects of natural disasters in Sri Lanka"* (Satarasinghe, 2017). Despite, *"The Colombo Municipal Council has its own planning, construction, engineering, and development divisions"* (Amarasuriya and Spencer, 2015). Another more compelling and

[15] Analysis of the future rainfall data of Colombo reveals that several extreme weather events with very heavy rainfall may occur in the future. Also, possible climate changes in Colombo will affect the existing and future rainwater harvesting (RWH) systems (Lo and Koralegedara, 2015).

counter balancing hinge is the country's mission on vulnerability prevention. The ministry of disaster management (2017b) points that their mission is *"to facilitate harmony and the prosperity and dignity of human life through effective prevention and mitigation of natural and man-made disasters in Sri Lanka"*. Thus, present study's objectives will be helped to fulfill the main aspirations of the country in terms of promising resilience and safe livelihoods. Therefore, an investigation of existing social integrations in terms of building resilience and coping capacities to adverse natural effects like flood inundation will be significant.

1.4. Scope and theoretical background

Theoretically this research links with two broad research paradigms. One is the vulnerability and livelihood research. This research area has been very closely interlaced with the broad context of human geography. By contrast, a spectrum of natural disasters and phenomenon are becoming worse and the risk has been augmented as those disaster events are being highly affected to the human being and their livelihoods. Adverse consequences of these phenomenons have been investigated by a plethora of research applications mainly under the theme of vulnerability research. By contrast, in Adger and his colleagues' words; *"How and why populations are vulnerable to environmental hazards has been central to geographical research for many decades"*[16] (Adger, *et al.* 2016). Mainly scholars, for instance (Chambers, 1989, 1995; Adger, 1999, 2003, 2006; Adger, *et al.,* 2017; Cutter, *et al.,* 2003; Cutter, 2010, 2017; Cutter and Emrich, 2006; Cutter, *et al.,* 2014; Bohle, *et al.,* 1994) have been theorized vulnerability research in plenty of ways. The second broad research area in which concerned in this research is social network analysis (SNA) research. The notion of social networks research has been theorized, for example, (Wasserman and Faust, 1994; Jackson, 2008; Newman, 2010) in terms of analyzing social interactions in the context of geographical space. Also, social networks research has been linked with the social vulnerability analysis (Zakour and Gillespie, 2013; Waters and Adger, 2017; Jones and Faas, 2017) as social networks are being considered as one of the main metaphors in the context of social capital building (Leenders and Gabbay, 1999; Araujo and Easton, 1999; Sabatini, 2009; Musalia, 2016; Story and Carpiano, 2017). Therefore, the theoretical background of this study is belonged to the both broader research areas; social vulnerability and social networks by the ways in which categorized under the

[16] *"Much theory and empirical research convincingly explains how structures in society determine vulnerability, with perspectives on how collective action, agencies, and the state coalesce in constructing and reshaping the distribution of risk" (Adger, et al. 2016).*

epistemology of human geography.

1.5 Organization of chapters

This dissertation has compiled into seven main chapters including the first chapter. The second chapter is aimed at to analyze the existing body of literature on social network analysis, social capital, and social vulnerability. And also it discussed some of interrelated empirical applications among one another and mostly related empirical models.

The third chapter discusses the methodological backgrounds and all the procedures that used for the empirical data analysis with detail accounts for empirical data processing and all study areas. Third chapter also comprises the more details about study areas, statistical applications, and measures of some of key vulnerability variables.

The fourth chapter examines the resultant measures and characteristics of socio-economic networks, the reciprocal supports legacies and resources mobilizations in the flooding events. And also, it demonstrates the temporal and spatial evolutionary patterns of socio-economic networks by examining network graphs. More importantly, it has examined that the socio-economic network behaviors and their evolutionary patterns in related to 21 local admin units and key flood inundation phases (before, during, and after). The organization network behaviors also examined in this chapter.

The fifth chapter presents the role and the efficacies of social capital legacies in the flood inundation events. The epistemology of social capital is very broad comprising both structural and cognitive components. In particular, chapter four covers mainly the networks part (structural). Fifth chapter mainly implies the cognitive part of social capital. Nevertheless, some of section like groups and associations has intertwined with the notion of socio-economic network. In contrast, structural and cognitive notions have complementary associations.

The sixth chapter reveals the results of multi facets composite social vulnerability indexes and IPCC framework based vulnerability index while ensures the spatial patterns of social vulnerability to flood inundation with vulnerability mapping. This chapter also exemplifies the differences of vulnerability distribution between sectors and among local administrative units more comprehensively.

The seventh chapter discusses the key findings, research gaps and theoretical implications, policy implications of this study, future research potentials, and some of limitations incurred during the research process. It will be worthwhile the suggested potential policies in order to support to solve the existing problems in particular in the affected regional geographical settings.

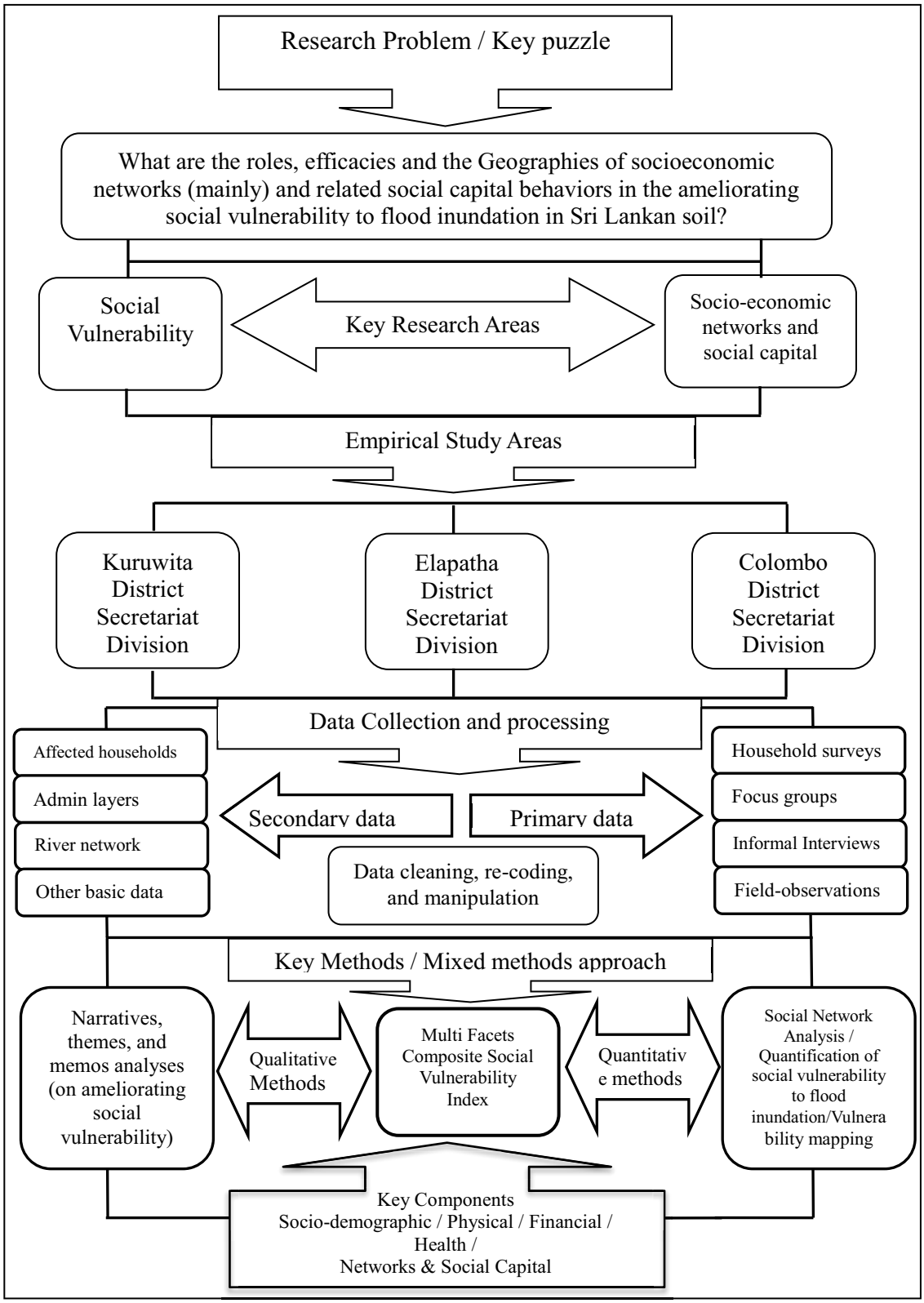

Figure 1.3: Brief overview of Research Framework

Chapter 2. Literature review and conceptual background

This chapter mainly relied on two broad conceptual research areas. Mainly, the study problem is based upon the vulnerability to flood inundation, which is one of the burning dilemmas in Sri Lanka, as a developing country. The socio-economic dimension of resilience on livelihood vulnerability to natural disasters has been well documented. Secondly, the study will be comprehensive in examining the role and the efficacy of social networks in the context of coping and resilience of livelihood vulnerability to flood inundation. Over the recent years, the significant influence of social networks on disaster management and mitigation has importantly been concerned. In this context, theoretical backgrounds and their real-world research applications are need to be reviewed thoroughly for a better and comprehensive study foundation. Henceforth, both the research areas, their conceptual and contextual backgrounds, variegated applications, methodologies, pros and cons, novelties, rejuvenations, impediments, implications, and new arguments will be examined elaborately in order to reinforce and sharpen this study's arguments. In particular, in the natural disaster situations (before, during, and after) the role and the efficacy of social networks are significant in coping, adapting, and resilience processes. Therefore, this section presents the broad sense of social networks particularly in the context of disaster analysis.

2.1. Social networks

In the words of M.E.J. Newman "*a network is, in its simplest form, a collection of points joined together in pairs by lines. In the jargon of the field the points are referred to as vertices or nodes and the lines are referred to as edges. Many objects of interest in the physical, biological, and social sciences can be thought of as networks"* (Newman, 2010, p.1). Thus, in the scientific study of networks, such as computer networks, biological networks, and social networks, is an interdisciplinary field that combines ideas from mathematics, physics, biology, computer science, the social sciences, and many other areas. In this context, a range of networks, for example, social networks, trade network, telephone networks, power-grid, transmitting networks, citation networks, transportation networks, delivery and distribution networks, internet, biological networks, and river networks etc. can be found. Almost all the networks are being linked with human beings. Particularly, the networks which are much closed to the day toady human activities and lives are very famous among research applications. This is

because, networks of relationships play central roles in a wide variety of social, economic, and political interactions (Jackson, 2008, P.13)[17]. Therefore, especially, scientists who are belonged to varieties of fields have been developed different kinds of tools and procedures in order to understand, analyze and model the networks (Newman, 2010, P.2). These insights interrogate the significant of dynamically ever expanding networks particularly in the human ecology.

2.1.1. Conceptual background of social networks

It is noted that, before the 20th century, social networks' strength had been confined to very short distance in terms of travelling or communication with letters. This situation has rapidly been changed since the 1950 decade with state-of-the–art technologies such as videoconferencing, TELE, and with a range of telephones (Da Costa *et al*., 2008, P.1). Through the notion of network, there has been propelling "public fascination" the ways in which making many ties of modern society with such a complex "connectedness" during past decade. This advancement has been solely based on the networks (Easley and Kleinberg, 2010, P.1). Particularly in the developing countries, social networks have been becoming key figure for mutual insurance in terms of improving social and economic lives. Trade-off of information, goods, resources and services among actors are important aspects of these networks (Jackson, 2008, P.17). For Lee and colleagues (2008, P.27), with the building of connections, a range of ties have been developed connecting people, organizations, and even websites together by means of friendships, provision of information, and complex ties in the web. This is because the many of ties, a plethora of disciplines are bound with the social networks studies. For instance, Feng and Lau (2008, P.99), *"the social networks (SN) (including social behaviors) seems to be a research topic in multiple disciplines, such as modern sociology, anthropology, sociolinguistics, geography, social psychology, communication studies, information science, organizational studies, economics, and biology"*. Feng and Lau have added the Geography in their list because of the social networks is embedded with spatiality which is the inherent core of the discipline geography. The geographical proximity of people has been the pivotal notion for forming relationships among them. Thus, network characteristics have tightly been linked with the spatial context (Editorial, 2012). This notion very broadly discusses and has been applied in modern economic geography, for example, tacit and codified

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[17] for example, Kolaczyk and Csardi (2014, P.1), *"the oft-repeated statement that 'we live in a connected world' perhaps best captures, in its simplicity, why networks have come to hold such interest in recent years"*.

knowledge which flow through the local buzz and global pipelines is totally depend upon the social networks. Hence, the spatiality is one of the key deterministic factors in which social networks behaviors and their topologies have been shaped.

According to Jackson (2008, P.13), for a range of relationships by means of societal, economic, and political aspects networks have importantly been playing a crucial role for integration them together. Thus the applications of social networks have been augmenting very rapidly. For example, Padgett and Ansell (1993) carried out a famous research on Rise of the Medici and the accumulation of power and applied a social networks approach. They have analyzed that the "Political" and friendship block-model structure on 92 elite families and revealed a strong family relationship behind the rise of the Medici[18]. Jackson (2008, P.20) points that *"…to the extent that marriage relationships were keys to communicating information, brokering business deals, and reaching political decisions, the Medici were much better positioned than other families, at least according to this notion of betweenness".* As well, in the public health sector, the influence of social networks has been widely examined. Emily K. Brunson has conducted a research to examine and quantify the impact of social networks on parents' vaccination decisions. For Brunson (2013), *"parents decide whether their children are vaccinated, but they rarely reach these decisions on their own. Instead parents are influenced by their social networks, broadly defined as the people and sources they go to for information, direction, and advice"*. The revealed results strongly suggest that social networks, and particularly parents' people networks, play an important role in parents' vaccination decision-making. Julie Leask and colleagues occupied with a research on mothers' vaccination decisions when challenged by anti-vaccination messages (Leask, *et al.,* 2006). Their study also found that mothers' decisions on to obtain vaccination have solely depended upon their network actors' influence such as parents, spouses, friends, and rest of ties. Opel and Marcuse (2013) also proved that the social networks greatly potential for recognitions of the advantages for decision making on immunization.

Similarly, social networks behaviors on other social aspects also have been thoroughly documented. Mora and his colleagues proposed a set of techniques for management of social networks and their integration into the educational process (Mora, *et al.,* 2015). Their findings revealed that social networks pervasively have more capacity to spread information than educational web platforms. Garcia and colleagues (2011) have carried out a research on the understanding and usage of

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[18] For Jackson (2008, P.18) *"Padgett and Ansell provide powerful evidence for this by documenting the network of marriages between some key families in Florence in the 1430s".*

social networking sites (SNS) as a "knowledge management (KM) tool in knowledge-intensive enterprises" and found that social networks advanced for making significant novelties, propelling productions, if they captured and shared information and knowledge in greater extent. Verdery and colleagues have analyzed that how kinship networks and dyadic ties associate with the patterns of juxtapositions of shelters in rural villages and have applied with network graphs to depict their positive relations (Verdery, *et al.*, 2012). Daraganova and colleagues have done a seminal research work on the geographical embeddedness of individuals in modeling social networks by using the exponential random graph models (Daraganova, *et al.* 2012). Their analysis suggests that spatial as well as endogenous networks influences need to be considered in order to explain the evolutionary and organized networks structures. Also, there are many studies which attempted to study the efficacy and applicability of social networks in terms of disaster and risk management are examined in the social capital and vulnerability section in detail. According to the above facts, the social networks can be identified not only as the emerging research foci in the analysis paradigm of the geography of human ecology and its phenomenon but also as the gaining momentum of the rethinking of primitive social integrations.

2.1.2. Measurement and representation of social networks

Particularly social networks analysis in the discipline like sociology accounts such qualitative approaches rather than occupying with the quantitative measurements. Importantly, in the disciplines like geography and some of spatial sciences have been used quantitative approaches to analyze and represent the social networks. In addition, these approaches have been drawn much attentions corresponded with their more impressive visualization prowess. This is because, the state-of-the-art technologies which used in the relevant software developments. In this context, much of contemporary research applications have been applied quantitative network analysis approaches.

Network graphs

Generally, in many social network applications, random graph models have been used because of their development process is stochastic inherently. This probabilistic nature makes very complex structures as a spectrum of actors are being linked with the social networks (may be called 'sociograms'). For Newman (2010, P.398), *"in general, a random graph is a model network in which some*

specific set of parameters take fixed values, but the network is random in other respects. One of the simplest examples of a random graph is the network in which we fix only the number of vertices n and the number of edges" m[19]*. a completely random process is responsible for the formation of the links in a network. The properties of such random networks provide some insight into the properties that some social and economic networks have"* (Jackson, 2008, P.25)[20]. In this notion, *"consider a set of nodes N = {1,…,n}, and let a link between any two nodes, i and j, be formed with probability p, where 0 < p < 1"* (Jackson, 2008, P.26)[21]. The network is seemingly "a bipartite network" in which nodes appeared in two groups 'male' and 'female' and the ties are possible to be seen between the groups (with few of other ties) (Jackson, 2008, P. 22). In general, these types of graphs depict rather good visualization impressions about the social network context. A range of networks graph categories are possible to be identified in the social networks context, for example, directed and undirected graphs, weighted and un-weighted graphs, weighted-directed graphs, weighted-undirected graphs etc. Also, these kinds of networks graphs consists mathematical structure which representing the nature of relations of each and every node. This is representing by the '*adjacency matrix*[22] ' and it implies that what kind of node is adjacent to one another. According to Jackson (2008, P.41), some of graph structures have been representing importantly some of possible 'multiple relationships' between different actors such as friends, neighbors, relatives, coworkers with different ties. He referred them as "*multiplex networks".* Moreover, in accordance with the nature

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[19] According to Newman (2010, P.399), *"this model is often referred to by its mathematical name G (n,m). Another entirely equivalent definition of the model is to say that the network is created by choosing uniformly at random among the set of all simple graphs with exactly n vertices and m edges".*

[20] Network properties such as the nature of ties in which related with different nodes, the ability to find paths between nodes and their connectedness, the lengths of their ties, and the number of individual or isolated nodes in networks have often been investigating in network studies (Jackson, 2008, P.25).

[21] "*Thus the model G(n,m) is correctly defined as a probability distribution P(G) over all graphs G in which P(G) = 1/Ω for simple graphs with n vertices and m edges and zero otherwise, where Ω is the total number of such simple graphs (Newman, 2010, P.399)".*

[22] *"The most common form of matrix in social network analysis is a very simple square matrix with as many rows and columns as there are actors in our data set. The "elements" or scores in the cells of the matrix record information about the ties between each pair of actors. The simplest and most common matrix is binary. That is, if a tie is present, a one is entered in a cell; if there is no tie, a zero is entered. This kind of a matrix is the starting point for almost all network analysis, and is called an "adjacency matrix" because it represents who is next to, or adjacent to whom in the "social space" mapped by the relations that we have measured" (Hanneman and Riddle, 2011).*

of relationships, particular paths, path-length, diameter, walks, and cycles can be identified. Also, graphs structure may represent some of associations as trees, forest, stars, circles, complete networks, sub-graphs (cliques), dyads, triads etc. These network rudiments will be crucial in the analysis phase of the structures of social networks in the vulnerable households. For instance, more cliques may create advantages to receive satisfactory assistants in the disaster events. According to abovementioned insights and ideas, networks graphs, their structures, and the nature of relationships and ties have been most important aspects in the network studies.

Degree, degree distribution, and centrality of social networks

The notion of the degree of social networks is similar to the other types of networks as it stands for the similar meaning. The degree implies that the nature of connectivity of nodes with each other. In other words, number of connections which one actor running with other actors in a network. According to Newman (2010, P.9), the degree of a node (or vertex) implied that the number of ties (or edges) in which linked with the node we consider. For an instance, regarding the friendships networks, each and every individual has different number of friends, the notion of numbers of friends represents the one's degree of his or her networks. Degree has been interlined with two different ties called, directed and undirected networks and only one degree (value) attached to the undirected networks. In the directed networks, they have two different degree types called in-degree and out-degree and in-degree implies the number of links directing inward and out-degree corresponds for outward links of vertices. This can be identified as an instrumental measure of social cohesion in social networks. Boessen and colleagues, for example, the degree of a network has been related with the structure of the cohesion which representing the number of social ties in the neighborhood related to such relationship. Therefore the degree to which one's attachment to each other has been increased in accordance with the connecting with more people, in other works, having more ties with others (Boessen, *et al*., 2014). I addition, "*it is an interesting observation that many networks are found to contain a small but significant number of "hubs"—vertices with unusually high degree. Social networks often contain a few central individuals with very many acquaintances*" (Newman, 2010, P.9). They may play seminal roles in social networks perhaps as leaders. For example, regarding this study, the Grama Niladari Officer (GNO) who is the village level responsible government official for villagers' all admin matters. In accordance with the networks investigations, GNO identified as the key actor particularly in flood networks. According to Jackson (2008, P.52), the degree

distribution can be identified as the basic as well as important characteristic of a network. Eubank and colleagues modeled the disease outbreaks in related to urban social networks and analyzed in and out degree distribution in terms of locational outbreaks (Eubank *et al.,* 2004). Degree centrality[23] also an important component in the social networks in which actors' position and strength is expressed (Kolaczyk and Csardi, 2014, P. 101). For Wasserman and Faust (1994, P.178), in accordance with the 'actor centrality', large number of ties with others of a network are related to the central actors of networks or graphs. They are more active in the networks activities rather than the rest of actors. According to Newman (2010, P.169), a spectrum of studies which are related with networks analysis have mainly been concerned the notion of centrality. The very simplest form of the centrality measure is the degree centrality in the social network analysis. The way of representing the degree centrality is that the dj (g) / (n-1). Moreover, other categories of centrality such as eigenvector centrality ("*a natural extension of the simple degree centrality is eigenvector centrality*"), closeness centrality ("*the mean distance from a vertex to other vertices"*), betweenness centrality ("*measures the extent to which a vertex lies on paths between other vertices"*) (Newman, 2010) identified as important measures of social network analysis. Closeness and betweenness centralities implied the nature and the characteristics of networks actors and the specialties of their roles or behaviors in their networks (Ceddia, *et al*., 2017; Kim, *et al.*, 2011).

Clustering and Cliquishness, Structural holes and Ego-centric networks

According to Jackson (2008, P.57), the clustering of actors in a networks can be identified as the kind of influential aspect of social networks. For instance, ones' friends are being tied with each other may represent kind of clusters. A plenty of concepts can be found in related with the notion of very close and tightly knitted networks. This idea has been evolved as the cliqueness in the networks studies. *"A clique is a maximal completely connected sub-network of a given network"*. Generally in order to form a clique, there is a necessity to have at least three nodes in a network. Jackson (2008, P.58), also pointed out that, one of the best ways to

[23] In networks environment, the actors who engaged with more ties can be identified as the advantaged position. This is because, regarding the resource exchanging, and fulfilling of actors' need, they do not need to depend on the few individuals as they have other alternative ways. In other words, they have many access paths in their networks. They are receiving a range of benefits from that brokerage as third parties and dealmakers. Therefore their 'power potentials and centralities' can be measured by the degree distribution (Hanneman and Riddle, 2011).

measure the cliqueness of a network is that the "clustering or transitive triples" nature of regarding that network. For Newman (2010, P.202), there is a close association between clustering of network and its 'structural holes'. In other words, the nature of clustering of network implies that the existence of structural holes pertaining to that network. Particularly in the network settings, there can have many ties in which related especially with neighbors and in some circumstances, the missing or less ties possible to be occurred in that network. With the situations of expected missing ties, the structural holes are formed (figure 2.1).

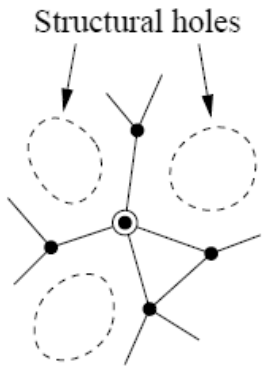

Figure 2.1: The formation of structural holes in situation where the neighbors of a node are not connected with each other.
Source: (Newman, 2010, P.202).

Structural holes are possible to have some of consequences on the reciprocal activities of a network. Especially, coping, adaptation, and resilience processes of disaster events, these kinds of structural holes in the social networks may have negative influences for ameliorating vulnerability of livelihood. Malm and his colleagues revealed that the more structural holes in marijuana growers' network have more risks on low enforcement against them (Malm, *et al*., 2017). On the other hand, for example, (Eubank, *et al.,* 2004), regarding the rapidity of decease spread, the clustering and degree distribution has been made greater impact at kind of short-terms notion and 'global graph properties' influenced for long term dynamics. Bodin and Crona's (2009) research on social networks in natural resource governance revealed that mainly measures such as density of relations, degree of cohesiveness, subgroup interconnectivity, and degree of network centralization are interlinked with the process of governance and outcomes (figure 2.3). Ego centered networks also are very crucial in the network structure formation. Wasserman and Faust (1994, P.42) emphasized that *"an ego-centered network consists of a focal actor, termed ego, as set of alters who have ties to ego, and measurements on the ties among these alters. For example, when studying*

people, one samples respondents, and each respondent reports on a set of alters to whom they are tied, and on the ties among these alters. Such data are often referred to as personal network data". For Newman (2010, P.44), often, ego-centered networks (also known as 'ego-centric or personal networks') implies its characteristics with one particular individual pertaining own "individual surveyed (ego) and its friends or contacts called alters (figure 2.2).

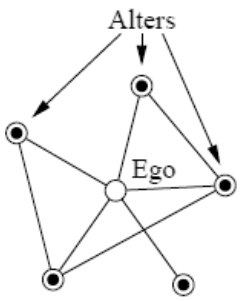

Figure 2.2: An ego-centered network consisting of an ego and five alters, Source: Newman, (2010, P.44).

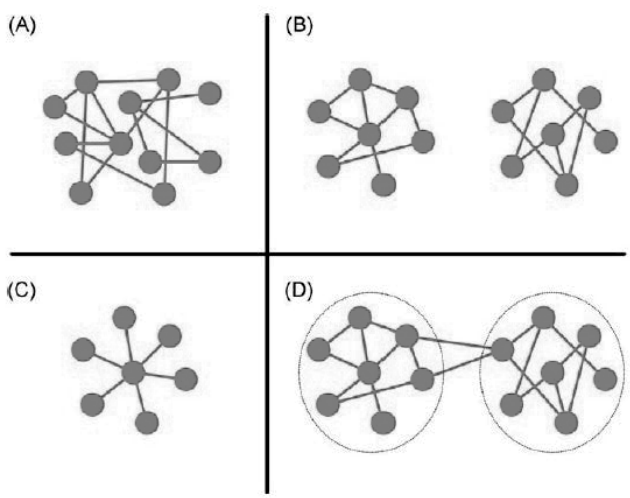

Figure 2.3: Schematic presentation of some of network topologies; A - social network without subgroups, B - with two isolated subgroups, C - a highly centralized network with higher degree centrality, D - two distinguishable groups interconnected through two bridging ties
Source: (Bodin and Crona, 2009).

Zakour and Gillespie (2013, P.120) views that regarding the vulnerability theory and related notions have associated with the ego as well as secondary ego networks and complete networks. Waters and Adger's (2017) study has been used

the ego-networks in order to analyze the social capital behaviors, social dimensions, and individual's social networks. But, they didn't provide graphical illustrations of social network depicting the social network behaviors of their study. According to Verda (2017), egocentric networks data (in the other words, personal networks data or egonets etc.) are very instrumental especially for the disaster management situations when the ego-centered networks are densely connected with the rest of the networks. Thus above discussed social networks conceptions are very important and related for the present study.

2.1.3. Social capital and social networks

Social capital[24] is the wealth of public which formed tangible and intangible resources collectively enclosed together for the benefit of human being. Also, social capital has some of complementary association with social networks. However, this insight yet to be shaped in accordance with the experts ideas and applications not only for the better understanding of the conception of social capital but also to the precise application in the present study. Therefore, in this section, I will examine the conceptual notion of social capital and then the efficacy of social networks and social capital in terms of disaster preparedness and recovery.

Societal collaboration and cohesion have been well documented in the existing body of literature. Particularly in the disaster events, their intertwined nature with each other had been helped to mitigate the adverse effects and consequences of disasters. According to the extant literature, a range of definitions can be found on the context of social capital. Because of the epistemology of social capital is characteristically diverse, complex, and multi facets conception which mainly has been interlinked with the notion of social network. In contrast, social relations, associations, helping each other, bonding with neighbors etc. all are resources of social capital. Thus, the key aspect of social capital is multidimensional which comprises of a range of societal values, such as collaboration and trust, collective actions for mutual benefits, freely given contributions, sharing information, associational relationships and social norms, ensuring each other's wellbeing, the exchange of favors, the exercise of sanctions, and also as precious asset etc.

[24] Burt's insight on social capital implies some fundamental notion to the question of what is the relation of social capital with social networks. Social capital represents the person's location in such a structure of associations. That means, the location of individual in a network determines the background of social capital of related to that individual. Also it has some complementary bond with the human capital. Thus, their relations, trust, and reciprocal exchanges determine the status of social capital (Burt, 2005, P.4).

(Coleman, 1988; Putnam, 1993; Burt, 1997; Narayan and Pritchett, 1999; Grootaert and van Bastelaer, 2002; Başaran-Uysal,2014; Villalonga-Olives, Wind, and Kawachi, 2018; Nawinna and Venable, 2019) in terms of building societal networks in order to secure their lives and revive affected livelihoods by all the means when they need. Regarding the recent interest of the notion and the complexity of defining, Bandaralage (2009) pointed out that in the recent years the conception of social capital has widely been discussed in a range of disciplines especially related to the social science scheme. Nevertheless, up to yet, there has been no generally accepted definition or measuring procedure of social capital. This is because, *"social capital is usually seen as a fixed asset, a property which individuals or in some cases communities possess or do not possess…. It has always been controversial and is subject to a growing weight of critique….In some cases social capital arises entirely naturally and social capital may be seen as an inevitable consequence of human sociability"* (Pathirage and Collyer, 2011). J.S. Coleman has theorized the conception in a very broader sense, for instance, he tried to understand the social capital in accordance with related functionalities to the conception. The conception is difficult to understand as a single entity and has cooperated with the several entities, mainly two elements identified. Firstly, they are facilitating with functionalities of persons or cooperate actors and they all are belonged to some of social structures. Secondly, social capital is similar to other types of capitals in terms of productive notion with some ultimate achievements and it is often persisting (Coleman, 1988). Coleman's arguments encapsulated that the differences of social capital from other types of capitals and the complementary nature of its behaviors with others. According to Putnam (1993), the most crucial aspects of social capital are the networks, norms, and trust in which help to make enormous impacts on the mutual advantages. According to Leenders and Gabbay (1999, P.2), the theory of social capital has been spanned and pivotal through social, economic, and political research fields. They identified the social capital is as tangible or intangible (virtual) resources which potential to be received through actors' social ties in terms of fulfilling their goals (Leenders and Gabbay, 1999, P.3). This definition consists of both the 'relations' (may be networks) and resources which facilitate to fulfill the actors' needs. For Adger (2003), social capital can be identified within the context of economics I order to obtain public-private elements and based solely on actors' reciprocal activities, trusting each other, and reputations. This insight makes some inference to the notion of economic relationships to the social capital conception. Recently, for instance, Villalonga-Olives, Wind, and Kawachi (2018), explained social capital as different kinds of resources in terms of exchanging favors, dealing with group norms, trusting each other, and the provision of many other supports for the benefit of social groups. This implies that

the overall supportive nature of social capital in fulfilling of in advance of groups or networks members' needs.

In this context, the important query behind the conceptions of social capital and social networks is that how can we understand and distinguish the link between social networks and social capital? And also, secondly, do both conceptions have some complimentary interlinks?. Leenders and Gabbay (1999, P.3) identified social networks and social capital as different conceptions. Because of, "*a social network only conveys social capital if its social ties are beneficial for the attainment of goals*". Despite the facts that Araujo and Easton (1999, P.92) argued that social capital lies in the structure of social networks as they both involved with the social ties. Therefore, Amis (2002, P. 104) points that social capital possible to identified as the measurement of assets in which related with community, networks, and households. Locally, social capital facilitates with measures for the local issues and the measuring is quite problematic. Araujo and Easton (1999, P.81) further explained that the active participation and active relationships are foremost important in order to access social capital. According to Musalia (2016), as crucial assets, social networks may benefit for individuals and community through social capital. Network has been pervasive for enabling cohesion and many ties within many actors whether they are friends or not. Moreover, Story and Carpiano (2017) also views that social capital has been advanced with the community collaboration and social networks and the resources in which related to households or their members can be used for the achievement of individual or community (collective) goals. In this context, it is quite easy to understand the close association in between social capital and social networks behaviors[25]. Therefore, social network is one of the crucial metaphors in the process of social capital building in terms of reinforcing the vulnerable livelihood to natural disasters. By contrast, social network play a seminal role not only strengthening the social capital which supportive in the natural disaster situations but also providing and sharing information among actors in emergency situations.

According to the existing body of literature, the conception of social capital has some of sub categories and has been comprised with several characteristics. These are paramount important in terms of understanding the exact contributions to the related networks thesis of social capital particularly in the disaster events. Also, it will be crucial to determine the regional differences of its contributions as a multidimensional notion in nature. Social capital has been categorized into two

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[25] "*Also, it is important to be precise in the definition and application of social capital, as the term has been so broadly and differentially used that it is not always clear what it means"* (Jackson, 2008, P.105).

main forms, namely Structural and Cognitive (Krishna and Uphoff, 1999; Uphoff and Wijayaratna, 2000). Christiaan Grootaert and Thierry van Bastelaer clearly distinguished in their book (edited) that the nuance of both the forms, for example, *"Structural social capital facilitates information sharing and collective action and decision making through established roles and social networks supplemented by rules, procedures, and precedents. As such, it is a relatively objective and externally observable construct. Cognitive social capital refers to shared norms, values, trust, attitudes, and beliefs, and is therefore a more subjective and intangible concept"*. (Grootaert and van Bastelaer, 2002, P.3). Their insight implies that social capital comprised both tangible and intangible forms in which generate through comprehensive social ties. Nevertheless, conceptually there are some existing similarities, for instance, Uphoff and Wijayaratna (2000), urged that both are mental and cognitive forms rather than physical, also structural forms observable and structural forms observable. Based upon the structural nature, social capital further has been categorized into three forms; bonding, bridging, and linking (Grootaert, *et.al*, 2004). Bonding social capital exemplifies the taking place relationships, facilitate interactions and collective actions within or intra groups which are mostly similar in their demographic characteristics, for examples; family members, neighbors, close friends and work colleagues (Grootaert and van Bastelaer, 2002, P.12; Grootaert, *et.al*, 2004). For Faas and Jones (2017, P.13), kinship is a key relational variable, when bonding social capital worked at individual level. Bridging social capital describes the ties between or across groups with different demographic characteristics and mostly horizontal ties which able to have novel information and resources. Linking social capital refers to some of vertical ties connecting people to political and institutional context which are linked with power or authoritarian dynamics and or those in positions of influence in formal organizations such as banks, agricultural extension offices, schools, housing authorities (Aldrich and Meyer, 2015; Sanyal and Routray, 2016; Nakagawa and Shaw, 2004). In accordance with above-discussed insights and pints of views, bonding social capital has been involved within households or families and ties can be seen particularly between family members rather than outside actors. Bridging social capital is possible to be seen especially between households the ways in which connecting neighbors, friends, and the rest of network actors together. The linking social capital also important as it implies the quite strengthen ties between household members and outside actors such as local admin bodies, government organizations, charities and the rest of external bodies. Therefore, the complementary advancement of these three different relationships has been pivotal in terms of securing flood affected households by all the means.

Only very few studies can be found in the Sri Lankan soil on the influence of

social capital in reviving of livelihood in the disaster events (Karunarathne and Lee, 2019; Jayawardana, *et al.*, 2019; Minamoto, 2010). Other researches were concerned, for examples, on social capital benefits for the productivity of famers organization, Gal Oya, Sri Lanka (Uphoff and Wijayaratna, 2000); on erosion of 'productive' social capital in Sri Lanka (Bandaralage, 2009); on social networks, social capital and migrants (Pathirage and Collyer, 2011); on the effect of multiple dimensions of Social Capital and the moderating role of ICT on inter-bank strategic collaboration in Sri Lanka (Nawinna and Venable, 2019) etc. Therefore, this study will be filled and bridged the above gap by analyzing the influences of social capital and socio-economic networks on the flood inundation preparedness and recovery.

2.1.4. Social networks and social capital in the context of disaster preparedness and recovery

Due to the altruistic nature of traditional villagers, they easily faced and conquered the adverse situations even like some of unexpected natural encounters. The nature of natural disasters is unpredictable. This is because on the one hand, the most vulnerable areas are difficult to be projected precisely before they happen. On the other hand, evacuation activities which are operating from the outside possible to be blocked during the natural disasters as all the access ways are undergone congested. Therefore, socio-economic networks play a pivotal role in securing their members' livelihood. Similarly, in the flood disaster events, a majority of affected villages are isolated by surrounded water beams and external access has been blocked. Particularly in this juncture, their socio-economic networks are very active and actors are providing many helps, goods, basic facilities, evacuating plans, shelters for victims etc.[26] in terms of securing victims' lives and revivifying their livelihoods. In these situations, social capital and social networks may be the foremost and preeminent exponent in the village environment. Recently, there has been renewed interest on social networks and social capital studies in disaster contexts as it plays a pivotal role and working with greater prowess in reviving affected livelihoods. In contrast, many scholars have been theorized and examined that the crucial influence of social capital and social networks in the disaster situations. According to Faas and Jones's (2017, P.12)

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[26] For example, *"in the development literature, those communities endowed with a rich stock of social networks and civic associations have been shown to be in a stronger position to confront poverty and vulnerability, resolve disputes, and share beneficial information (UNESCO, 2002, P.28)".*

words, *"network analyses of disasters attempt to deal with the patterns of relationships that enable or inhibit individual, group, or organizational capacity to prepare for, cope with, adapt to, resist, or recover from potential or actual risks, hazards, and disasters. This full range is rarely considered in any one study".* This statement implies that the epistemology and the scale of networks studies in disaster context is very broad and consists of variegated aspects in plenty. Network structure is one of the crucial metaphors particularly in the disaster context. For instance, Faas and Jones further pointed out that it may basic requirement to examine the network structure help to understand the relational patterns and evolutionary dynamics in the disaster context. Especially, actors of networks have consciously been managed the structures of their networks in the disaster situations (Faas and Jones 2017, P.17). This may realistic as the people are being aware of the actors of their networks, and they communicate and arrange with key actors of their networks in order to helps others and prepare for disaster situations and that process incorporate with the structural notion of networks with or without knowingly. Specifically, reciprocity, mutuality, and egalitarianism are the key elements of network structure. Also, these elements encourage network actors to make contribution for equitable and responsible input (Kapucu and Demiroz, 2017, P.37). According to Li and Goodchild (2010), in the operative emergency management, networks are pivotal in two major roles; firstly, regarding the context of information dissemination and communication in the disaster response, networks play pivotal role, secondly, in order to strengthen a range of reciprocal services such as gathering and provision of information, evacuation management, provision of sheltering and the rest of supports, the networks relationships, their interactions, and behaviors are very instrumental. In this context, it can be postulate that the dense networks play a seminal role in revivifying and bolstering the victims' livelihood as well as making ease of life styles in the disaster events (particularly, before, during and after) by making enormous efforts. It has also been important to notice that the networks may be the salient notion of social capital particularly in reviving livelihood in the disaster contexts (see, Baird and Gray, 2014). Considering upon the present study, the important aspect of the account of social vulnerability investigation is that the position of social networks in the disaster situation like flood inundation. Regarding this notion, Zakour and Gillespie (2013, P.118) emphasized that the influence of networks has been shaped the level of vulnerability of communities. Particularly, the structure of both community and organizational networks has been effective before, during, and after disasters. Also, a range of reciprocal supports are being accelerated by the related networks structure.

Gillespie and Murty (1994) have conducted a study on cracks in a post disaster

service delivery network and provided viable evidence on the abilities of networks and disaster studies to encourage community awareness and overall planning process on service delivery. Also, regarding the privileged resource access, network has often been providing with greater opportunities for actors (Leenders and Gabbay, 1999, P.3). This study exemplifies the abilities of social networks in providing resources which is much potential in the disaster circumstances. Ben-Ezra's (2017) as well, highlights the importance of the individual within a social network and thus adds deeper insights to contributions of social networks and social support in coping with disasters. Also, Bryant, and colleagues investigated how social networks influenced building mental health after disasters (Bryant et al., 2017). Their study revealed that the there is a strong association between the network density and depression rate. By contrast, the depression has been increased with the lesser ties with other peoples and also they were connected with the peoples with similar background or with the people who isolated from their communities. Furthermore, the influence of social networks on diminishing of the consequences of loneliness and improving social confidence by decreasing social disability are highlighted (Sintonen and Pehkonen, 2014).

On the other hand, social networks play a seminal role in the notion of disaster preparedness, the ways in which identified as instrumental for reducing adverse effects. Eisenman and his colleagues point that *"historically, the messengers and messages used for disaster preparedness have been best suited to mainstream and easy-to-target audiences"* (Eisenman, *et al*. 2009). Kryvasheyeu, *et al.*, (2015), for example, their study on Performance of Social Network Sensors during Hurricane Sandy and found that *"differences in users' network centrality effectively translate into moderate awareness advantage (up to 26 hours); and that geo-location of users within or outside of the hurricane- affected area plays a significant role in determining the scale of such an advantage"*. Also, Song and Yan (2012) have done a study on emergency information spreading in online social networks. They found that network characteristic like degree distribution of actors including their structure has been more significant in many ways for the dissemination of emergency information. Kim and Hastak's (2018) study analyzed that the online social networks after a disaster. Their results show that individuals, emergency agencies, and organizations are three main pillars of social networks and the core consists of different kinds of individuals who are playing seminal roles on communication, information sharing, and updating information with the city of Baton Rouge. According to the facts that revealed by these studies, we can postulate that the social networks are being influenced disaster resilience in terms of building social capital. Also, these studies help to emic understanding of the significant and the necessity of social networks in order to build the coping and

adaptive capacities in the disaster situations.

In this context, particularly in the disaster situations, social capital is one of the foremost resilience components in ameliorating social vulnerability of livelihood (Adger. 2003; Cutter, 2006; Adger, 2006; Zakour and Gillespie, 2013), except the influence of other demographic characteristics (age, health, gender etc.). This is because, *"the vulnerability of households was influenced by the distribution of access to resources such as land, labor, capital, tools, information, social networks, and the expectation of resource provision from networks"* (Zakour and Gillespie, 2013, P. 51). This list contains the social capital facet at a greater sense and the rest components are representing the rest of components of resilience of vulnerability. Also, especially the public-goods (e.g. endowment of resources as described above) are a part of social capital which makes significant influence of adaptive capacity. A range of recent evidences have been proved that the influence of social capital in securing and reviving livelihood in the disaster situations has always been significant (Masud-All-Kamal and Hassan, 2018; Sadri, *et al.*, 2018; Wickes, *et al*., 2017; Sanyal and Routray, 2016; Bankoff, 2015; Joshi and Aoki, 2014; Reininger, *et al.*, 2013; Bihari and Ryan, 2012) while some of have investigated that the "dark side" or "unresponsive" linking nature of social capital e.g. (MacGillivray, 2018). According to Grootaert and van Bastelaer, social capital is more instrumental as it interacts with social interactions and attitudes even some scholars have argued about the use of the word 'capital'. Nevertheless, the characteristics of social capital clearly distinguish the concept from the rest of forms of capital (Grootaert and van Bastelaer 2002, P4).

For Buckland and Rahman emphasized (1999), social capital is a kind of "double-edged sword" especially in the context of disaster management. One the one hand, it is very efficient in the sense of mobilizing people when they need through the pre-existing collaborations helping each other. On the other hand, sometimes social capital has been acting in terms of delaying or blocking urgent decisions due to debatable ideas of network actors (Buckland and Rahman, 1999). Finally their study revealed that the advance level of physical, human and social capital have been crucial in responding flood and also concluded that, social capital is foremost important in emergency management. In accordance with my understandings and field observations, social capital has often been instrumental in the flood inundation preparedness (response) and recovery as regional level non-financial metaphor, especially when the outside supplies undergone block. I found a very early work which done by Howard Kunreuther, had paid the attention on the peculiar economic aspect in the disaster situation and pointed out that *"most supply and demand problems facing an area hit by a natural disaster are generally short-run in nature because of the aid forth- coming from outside regions. Even*

when the threat of shortages does exist, the concern of residents in the community for the plight of others helps to minimize serious problems during the emergency period" (Kunreuther, 1967). The important of this aspect is that the community collaboration is more robust particularly in the situations where the external supplies have been hindered. Particularly in the flood inundation situations, the down valley villages often have been isolated. Nagawa and Shaw (2004), identified that the local level social capital and networks which following to Kobe and Gujarat earthquakes, played a crucial role in recovery and response activities. Agrawal and Monroe's study on social capital and wildfire revealed that the greater social capital impacts to take more actions in order to reduce wildfire risk and helps to increase their knowledge and skills on wildfire mitigation practices (Agrawal and Monroe, 2006). Bihari and Ryan (2012), also, highlighted the similar narratives that the resulting stronger social capital leads to safer, more fire-adapted interface communities and the role of place attachment make the positive impact on it. Joshi and Aoki (2014) substantiated that the social capital plays important role in the process of establishing recovery policies for Tsunami affected areas in India and social capital viable in disaster recovery. According to Sanyal and Routray's findings, all the forms of social capital (bonding, bridging, and linking) have played a significant role during and after the Cyclone Aila up to some greater extent (Sanyal and Routray, 2016). This was mainly because, the societies which are in study area belonging to similar culture and common historical background. A recent study on the role of social capital, personal networks, and emergency responders in post-disaster recovery and resilience, was revealed that the households which have good recovery assistance from neighbors, belonging to strong personal networks, and higher level of social capital exemplified with faster recovery (see, Sadri, A.M. *et al*., 2018). Jovita and colleagues also have found that mainly bonding and linking social capitals of typhoon-affected communities are much rich and the trust among Filipinos has been linked to the social norms, and also, have been significant in resilience activities (see, Jovita, *et al*., 2019). In the application context, a range of studies have been proved that the positive and very stronger association between building social capital and disaster recovery in the community level.

2.2. Social vulnerability in the context of natural disasters

The term vulnerability is very broad conception which involved with a plenty of disciplines broadly from social sciences to natural sciences. For examples, (Adger, 2006), the conceptual and application contexts of the notion of vulnerability is differed from discipline to discipline (e.g. from social sciences to engineering sciences) as it covers very broader areas and they have been used the

term vulnerability. Therefore, it is quite difficult to make a common hermeneutics for the notion of vulnerability. In this context, this study considered the epistemology of vulnerability based upon the context of natural disasters in terms of floods, droughts, landslides, earthquakes etc. This is because the vulnerability to flood inundation has been theorized under the broad context of vulnerability to natural disasters in the body of literature. By contrast, the measuring components/indicators of vulnerability belong to variegated natural disasters are utterly analogous, since the vulnerability acts as a preeminent exponent to measure the susceptibility of livelihood to disasters. In the words of Adger (2006), for example, *"The concept of vulnerability has been a powerful analytical tool for describing states of susceptibility to harm, powerlessness, and marginality of both physical and social systems, and for guiding normative analysis of actions to enhance well-being through reduction of risk"*.

A plethora of definitions for the conception of vulnerability to natural disasters are available in the existing body of literature. According to Chambers (1989), the conception can be considered as a similar notion to the poor. Nevertheless, the vulnerability is impossible to be considered as poverty. It gives rather defenseless meaning with the situations of insecurity, stress, shocks, and exposure to risk perceptions. Chambers can be recognized as the first who elaborately described the conceptual notion of the vulnerability discourse which have been cited in many vulnerability studies. Chambers (1989) also noted that vulnerability consists of two facets; first one is the external aspect which incorporated with risks, shocks, and stress of individuals and households. Second is the internal aspect which has linked with lacks of coping capacities with possible damages[27]. His idea hints that the causative factors as the external side and the livelihood vulnerability variables or characteristics as the internal side.

Bohle and colleagues (1994) urged that, in particular, the people who are living with a range of economic hardships (e.g. poor people) are belonged to the most vulnerable portion and for the exact understanding there needed be some disaggregation in the structure of the notion of poverty within it. Therefore, vulnerability conception is needed to be included temporal sensitivities (e.g. seasonal) and geographical sensitivities (e.g. regional) and also their variations in which related to different societal groups' disaster response experiences. They have

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[27] This definition suggests three basic co-ordinates of vulnerability (see, Michael, 1993). *"(i).The risk of exposure to crises, stress and shocks (ii).The risk of inadequate capacities to cope with stress, crises and shocks (iii). The risk of severe consequences of, and the attendant risks of slow or limited recovery (resiliency) from crises, risk and shocks"*.

tried to make an emic understanding of vulnerability in a broad notion. On the other hand, Adger (1999), also emphasized that vulnerability is impossible to be considered as same for the people who are living with different environmental conditions and with different socio-political, resource endowments, as well as abilities (e.g. technological) and disparities and therefore the conception dealing with the condition of "well-being". Adger's insight implies that the livelihood status (like well-being[28]) is crucial in the vulnerability context and it varies accordance with different circumstances of people environment. The vulnerability implies such a complex notion as it consisting of many dimensions. Regarding Turner and colleagues' (1999) idea, for example, *"vulnerability is a multidimensional concept encompassing biophysical, social, political, and ethical factors"*. By contrast, in line with Adger (2006)'s insight that vulnerability to environmental hazards does not comprise the situation of existing from wider resource use. The conception has conceptualized by the magnitudes of exposure, sensitivity, and the adaptive capacity[29]. For United Nations (UN, 2004, P.41), vulnerability is not a single entity and it has multiple facets in plenty, individually or collectively work such as mainly socio-economic and physical conditions. These facets work in accordance with the conditions of socio-economic, cultural, and political as they influenced from individuals to whole communities. UN implies that such a comprehensive insights encompassing the broad conceptual context of vulnerability. Quite similar, insights revealed by Salami and colleagues (2017), highlighting that the conditions of factors such as physical, human, and socio-economic have been bringing the whole system including society prone to anthropogenic or natural disasters.

O'Brien and colleagues view that the broad meaning of vulnerability has been pervasive through the risk, effect, and adaptability (O'Brien, *et al*., 2007). O'Brien and colleagues have tried to frame the complexity of vulnerability through outcome vulnerability and contextual vulnerability [30] .Vulnerability represents the unsatisfactory and volatile conditions of entities such as individual, groups, or even

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[28] "*Well-being is the experience of good quality of life. Thus, well-being and ill-being refer more to experience, poverty more to physical lack, and deprivation to a much wider range of lacks and disadvantages*" (see, Chambers, 1995).

[29] This idea is almost similar to the insight what Pelling (2003, P.5) points that *"vulnerability denotes exposure to risk and an inability to avoid or absorb potential harm"*. Pelling urged that lacking coping (in his words 'inability to avoid or absorb') capacities make the vulnerability onerous.

[30] "*We conclude that the different framings of outcome vulnerability and contextual vulnerability make it very difficult to integrate them into a single integrative vulnerability framework*" (O'Brien et al. 2007).

human settlements etc. (Martínez-Viveros and López-Caloca, 2010, P.257). On the other hand, for example, Jabeen and colleagues (2011), view some different point, explaining that vulnerability has been associated with the dynamic nature of welfare or poverty including instability of living conditions and the abilities of households and their related norms to work again shocks. In collective notion of most of the vulnerability studies is that the reducing the adverse effects of disasters, for example, Zakour and Gillespie (2013, P.18), the level of vulnerability can be used as the main foci to reduce the impacts of natural disasters.

On this context, the majority of vulnerability studies focused on the collaboration of societies in terms of reducing the harms of disasters by all the means. Hence the discourse of vulnerability has covered a range of insights as well as beliefs (Adger *et al.,* 2017). Therefore, the consideration of vulnerability and societal capacity assessment has been pivotal in terms of developing disaster risk reduction strategies to revivify affected communities (e.g. Jamshed, *et al.,* 2019). Moreover, examining the aspects of resilience and assessing spatiality and geographical patterns of vulnerability distribution are also very important in terms of understanding the nuance of vulnerability conception and for applications (e.g. Borie, *et al*., 2019; Jha & Gundimeda, 2019). These insights are helped to demystify the circumference of the notion of vulnerability as such an ample hermeneutic.

2.2.1. Vulnerability in different perspectives and notions

In the existing body of literature of the vulnerability science, a plethora of insights and ideologies on vulnerability studies can be found. It is important to be analyzed the existing insights and arguments of vulnerability, in order to have a nuance understandings of conceptual naivety and then to integrate the relevant conceptions to the theme of my study. In this context, diverse perspectives of vulnerability conception will be examined. For the better understanding of the vulnerability of livelihood, their major forms and characteristics are needed to be evaluating with various dimensions which with applications have been enrolled. Most of vulnerability related approaches have generally been grappled with physical, social and institutional dimensions in order to analyze and understand the overall nature of livelihood vulnerability. By contrast, physical, social and institutional dimensions of vulnerability can be identified as the mostly cited metaphors of contemporary vulnerability studies.

Physical vulnerability (biophysical vulnerability)

According to Pelling, physical vulnerability has been incorporated with the

vulnerability in the built environment (Pelling, 2003, P.5). As Pelling views, physical vulnerability related to the surrounding environment characteristics of livelihood. For Dewan (2013, P.46), the characteristics of natural and manmade environments for examples, heights, geographical variables mainly with land uses practices, and the juxtaposition the causative sites are related with the physical vulnerability. By contrast, in accordance with the mostly cited literature, physical vulnerability has been belonged to many components, for example, environment, buildings and housing, various other infrastructures, geographic locations, economic activities, and also even land use practices such as agriculture etc. (Pelling, 2003; Cardona, 2004; Davis, 2004; Haque and Burton, 2005; Mace, 2006: Leichenko and O'Brien, 2006; Birkmann, 2006; Peduzzi, 2006; Carreno, *et al.*, 2009; Bizimana and Schilling, 2010; Jabeen and Johnson, 2013). The preeminent thing in which physical vulnerability implies is that it has inherently been interlinked with the livelihood where the inhabitations exist. Because of the vulnerability has been defined in the context of inhabited environment. This vulnerability may appear as the consequences of changes or devastation of physical environment by a range of anthropogenic activities[31]. Some authors like Cardona (2004) has argued that the physical vulnerability as a form of 'global vulnerability'[32]. Biophysical vulnerability in this context is a concept developed from global environmental change research (Birkmann, 2006, P.12). Researchers like Wisner (2004, P.186) views that the physical vulnerability possibly occurred due to the "week buildings or week individuals". However, Wisner's insight on 'individual' notion has to be clarified with the explanation of 'social vulnerability'. Davis (2004, P.136) also add 'agriculture' to the list of physical vulnerability rather than buildings and infrastructure[33]. According to Birkmann (2006, P.36), physical vulnerabilities are identified as the organizational and institutional aspects and the investigation should be considered through the economic, social and environmental pillars. This idea has some of similarity with the institutional vulnerability despite 'institutional vulnerability' has been distinguishing from the notion of physical

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[31] For example, according to Pelling (2003, P.105), *"the physical vulnerability of Barbados's housing stock is indicated by the frequency with which people have been rehoused following beach erosion or flooding"*.

[32] For Cardona (2004, P.39), *"Global vulnerability – a far more holistic and encompassing concept that goes well beyond issues of physical vulnerability. In developing countries, social, economic, cultural and educational aspects are, in most cases, the cause of the potential physical damage (physical vulnerability)"*.

[33] Wang and colleagues (2016), also occupied with *"risk assessment of physical vulnerability can help better understand the physical vulnerability to agricultural drought and can also promote measurements to adapt to climate change"*.

vulnerability, other than may have some of complementary relations. Jabeen and Johnson (2013, P.158) for example financial and human risks are exacerbated by the physical vulnerabilities in which made through natural disasters[34]. In some cases, social aspects are contrasted from the physical aspects[35]. According to the above context, Physical vulnerability can be assessed, for example, Bizimana and Schilling (2010, P.110) through examining infrastructure, housing, economic activities, geographic location and population density. However in accordance with Adger and colleagues' views, (Adger, *et al.*, 2003), the major problem is that there is no appropriate mechanism has been demonstrated by related scholars in order to identify successful adaptation in the developing nations which experiencing with mass risks and physical vulnerabilities.

Social vulnerability

According to the exiting body of literature of the vulnerability discourse, the conception of social vulnerability can be identified as the foremost exponent in terms of examining the vulnerability of livelihood to natural disasters, for instance flood inundation. Many of scholars have been identified social vulnerability in the similar meaning to the economic vulnerability. Perhaps, the reason behind that notion may be the prowess of economic context in ameliorating of social vulnerability of livelihood to disasters. However, both the concepts symbolize such a complimentary interlinks which bridging the gaps between each other. As Cutter (2017) points that "*social vulnerability most closely tracks with social and economic resilience*", therefore, my insight is, it is needed to carry out a comprehensive review of literature for a nuance understanding of conception. Thus, in this section, I will examine different components of social vulnerability in accordance with a range of different insights.

According to Birkmann (2006, P.13), it is difficult to find a generally accepted definition as different scholars have been described in different ways. Social vulnerability has been encompassing a range of aspects and meanings which with related to disasters and livelihood. This is because the social vulnerability is consisting of different components and variables which have been influenced the

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[34] *"In general, socio-political vulnerabilities exacerbate physical vulnerabilities*" (Jabeen and Johnson, 2013, P.155).

[35] Schneider and Lane (2006, P.33), socio-economic linkages and hierarchical models are considered by 'top-down' approaches for measuring of physical vulnerability. On the other hand, by considering the 'bottom-up' approaches, the lacking of accessibilities to basic needs (e.g. foods, healthcare facilities etc.), poor involvement of political institutions and poverty in related with individual and group levels are main concerned.

vulnerability of livelihood. Adger (2000), points that as the consequences of rapid environmental changes, individuals and groups of peoples have been exposed to different kinds of stresses. This situation is identified as the social vulnerability. Hence, the social vulnerability consists of livelihood disturbances and poor or "loss of security". Adger's view implies that the nature of the complexity of social vulnerability conception and its relations with environmental phenomenon. Pelling (2003, P.5), has added quite broader explanation and perception to the definition describing that, if people as well as their socio-economic and institutional (e.g. political) systems have been undergone with vulnerability, that situation identified as social vulnerability. Of course, there seems to be some complimentary links of social vulnerability as the people, their livelihoods and their systems have interlaced together. Another crucial aspect in which influenced the social vulnerability is that the socio-economic characteristics of affected people. According to Cutter and colleagues (2003), individual characteristics such as demographic (e.g. employment, health, age, race, etc.), household conditions, and economic abilities (e.g. income) exemplified their level of social vulnerability. On the other hand, social inequality among people is also a major reason for susceptibility to vulnerability and their resiliency protects them from hazardous events (Cutter and Emrich, 2006). These causative factors have been shaped the level of social vulnerability to disasters. This idea comprises characteristics as well as the main dimensions of social vulnerability which is one of the mostly cited ideas in the social vulnerability literature.

In the similar vein, for example, Cutter and Finch (2008), the conception of social vulnerability is inherently evolutionary and dynamic. Thus, the nature of social vulnerability is quite volatile and has been changing in accordance with the space and time. As Adger's (1999), earlier work emphasized, the volatile nature of social vulnerability is solely depend on people's socio-economic conditions. Therefore, in accordance with Paavola's (2006, P.205) view, due to the complex socio-economic relations with social vulnerability, finding of effective adaptation measures has often been difficult. Moreover, the debate become very complex with the human ecology conception, for example, Bohle and colleagues (1994), engaged with the related causations like "food insecurity", economic aspects, and social vulnerability to explain livelihood exposure to disasters. And also, the entitlement theory[36] implies another dimension of social vulnerability which intertwined with the economic aspect mainly concerning the access to resources or commodities.

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[36] The entitlement theory was firstly introduced by a Nobel laureate, Amartya Sen (1976), Famines as Failures of Exchange Entitlements, *Economic and Political Weekly*, 11(31/33), pp. 1273-1280.

Adger and Kelly (1999) gave some helping insights to the entitlement aspect, explaining that the resource use or endowment may be the crucial aspect of understanding the social vulnerability which is linking with the entitlement notion of social vulnerability. The abilities or entitlement of communities to own or use resources has been salient in order to strengthening up peoples' coping and adaptive capacities against the disasters and stresses. Income distribution, access to economic assets, political economy has also been pivotal in addition to livelihood entitlements in both individual and households level in the social vulnerability context (Adger, 1999). Wisner (2004, P.188) also accounted for the relationship between resourcefulness and social vulnerability. On these conceptual and contextual debates, it is clear that resourcefulness, entitlements, and the rest of the capacities of community (or individuals) have significantly been influenced to the coping capacities and social vulnerability level. By contrast, the social collaboration and reciprocal ties are influenced on the resourcefulness of the communities.

On the other hand, Barnett's (2006, P.117) idea about social vulnerability is quite similar to the notion of resource endowment and proper access. He explained the conception as different types of capitals. For instance, that is as the function of accessibility (and also availability) to human, social, economic, and natural capitals. Therefore, the extent to which accessibility to those capitals has been determined the coping and responding abilities of individuals as well as groups of people for disasters. This is because, availability and the accessibility of capitals are making the winners and losers who are "socially and politically generated (SPG)" imply that the social vulnerability (Leichenko and O'Brien, 2006, P.106). In accordance with my understandings, the notion of "losers" is especially attached to the countryside and rural as well as marginal areas in developing countries. As Ramachandran, and Susarla (2010, P.127) noted that the poor farmers and marginalized rural villagers have adversely been affected by the social vulnerability in which linked with the devastated environmental changes and their consequences (e.g. Ramachandran, and Susarla, 2010, P.127). In the sense of rural and marginal groups, for Dewan (2013, P.46), especially the social vulnerability of marginal groups has often been interlinked with their physical as well as infrastructural facilities, social fibers, and also mainly with their demographic characteristics. Perhaps, the climatic influenced on the creation of social vulnerability has widely been concerned. For instance, Dumenu and colleagues argued that social vulnerability identified as "the interplay between social, economic, and demographic characteristics" in which determined the level and the status of resilience of communities against climatic change (Dumenu, *et al.*, 2013, P. 412). At present, the discussion has become more comprehensive with the

addition of the adaptation and mitigation, for example, Cutter (2017) emphasizes that social vulnerability measures *"the susceptibility to harm from disasters. It permits the examination of the abilities of individuals and places to prepare for, respond to, recover from, mitigate, and adapt to hazards"*. On the other hand, as I deeply discussed in the social networks and social capital section, the social collaborations and ties have crucially been ameliorated the communities' susceptibility to stress by natural disasters, as this notion has interlaced with my main research puzzle which is the influence of socio-economic networks on flood disaster preparedness and recovery.

2.2.2. Determinants of social vulnerability

A spectrum of drivers and determinants are being linked with the social vulnerability and the degrees of influence are depending upon the conditions of livelihood and other socio-economic, demographic, and political circumstances. Particularly the people, who are economically poor, marginalized, and also poor in demographic status are more susceptible to the social vulnerability. This is because the social vulnerability is depending on the geographically variegated social backgrounds and settings. However, my argument is ((which is with my personal experiences with living (I lived more than 31 years until I got marry) in very rural and marginalized area, in Sri Lanka)), socio-economic network is may be the only panacea (or more instrumental for rural villagers in the disturbance situations like flood inundation for ameliorating their social vulnerability.

Many scholars have been identified demographic, socio-economic, political and geographical or locational factors as mostly influential drivers of social vulnerability (Adger, 1999, 2006; Cutter, 2003, 2008, Pelling, 2003; Wisner, 2004; Barnett, 2006; Birkmann, 2006; Cutter, 2010, Maantay, *et al.,* 2010; Dewan 2013; Otto, *et al.,* 2017). According to Adger (1999), the causative factors of vulnerability are basically being linked with economic and institutional aspects in which also been triggered with the environmental threats. This is because, for example, as Kliot (2004, P.84) points, *"unsafe conditions" of people or their environment are often vulnerable as "dynamic pressures 'translate' the effects of root causes into the vulnerability"*.

Cutter and colleagues (2003) listed common causative factors which have been used in the social science disciplines to determine the influence for the status of social vulnerability. These include; *"lack of access to resources (including information, knowledge, and technology); limited access to political power and representation; social capital, including social networks and connections; beliefs*

and customs; building stock and age; frail and physically limited individuals; and type and density of infrastructure and lifelines". Here, they have revealed one of the important points is that the '*social capital including social networks*'. Access of information, technology, and knowledge, also access to resources are depending upon the social fabrics and their collaborations. Thus social network is crucial in resilience, for example, Birkmann (2006, P. 19), regarding the vulnerability context, the notion of exposure deals with a range of social and institutional interactions, and if someone undergone with the exclusion from her or his networks, she or he is potential to be defenseless and being with grater possibilities to meet with stresses from such encounters like natural disasters.

Another significant component of social vulnerability is the age groups of people. For Cutter (2010, P.25), age identified as a critical component for vulnerability measurements. Especially, old-aged people and children are more sensitive on the context of vulnerability and they need to have special care among others. This is especially needed for the persons with disabilities and with some inherent weaknesses in obtaining and mobilizing resources. Therefore, more importantly, old aged people and children have noteworthy correlation with the social vulnerability. This may because they are more susceptible to the hazards, as well as population aging links with a range of demographic issues. Gender also remarks such variability among social vulnerability components. Because of the women are to be more vulnerable to disasters inherently compare to the men's inherent prowess which made by the nature. Thus, men have a great responsibility to secure their relatives particularly their children and women in the context of unexpected encounters.

Wisner (2004, P. 187) pointed out that *"social vulnerability is not a permanent property of a person or group but changes in respect to a particular hazard. Muslim women in Bangladesh never climb trees and are reluctant to leave the seclusion of their homes, so they are more vulnerable than men in a flashflood or storm surge".* This is because floods affect human populations in many ways, for example, physically and psychologically. Therefore, population density is regarded as one of the most important indicators in determining social vulnerability (e.g. Dewan, 2013, P.149). Particularly, for instance, Jabeen and Johnson (2013, P.150), the status of households or their settlements are such significant factors for determining their vulnerabilities. Because of, especially people who are living in the informal settlements are hazardous and comparatively more susceptible for natural disasters. In accordance with my personal experiences in which proved at the field observations, all most all the dwelling units (e.g. slums and shanties) which are located related to the informal settlements in urban areas are highly prone to natural disasters like flooding events.

Income and entitlement [37] notions are pivotal factors in the analysis of vulnerable livelihood. The economic and the entitlement components of social vulnerability analysis have been mesmerized among scholars as those causative factors are rigorously intertwined with the vulnerable livelihood. This component elaborates the notion of poverty of livelihood we concern. According to Adger and Kelly (1999) for example, regarding the context of income diversification, particularly inequality of income distribution has directly been interlinked with the poverty and then vulnerability. By contrast, when households are facing with the unexpected encounters, the inequality and poverty directly act as main obstacles to escape from vulnerability or inversely increase the level of vulnerability. However, it also includes the "place inequalities" which influence for their level of vulnerabilities. Especially, some areas are richer mainly in urbanization and economic growth compare to the rest of areas (e.g. Cutter, *et al.,* 2003). These kinds of place vulnerabilities have been linked with the characteristics of households and their members. Another aspect of vulnerability factors is that the entitlement as I discussed earlier. For Adger and Kelly, *"the factors which determine levels of social vulnerability define how the pattern of access to resources is constructed; this construction can be termed the 'architecture of entitlements'. The extended analysis of the architecture of entitlements allows considerations of both positive and normative aspects of social vulnerability are both implicit in all climate impact assessment"* (Adger and Kelly, 1999)[38].

Figure 2.7 depicts a broad notion of vulnerability research evolution with considering the entitlement approach and other rest of components in which exemplify, with some complex relations. United Nations' human development index (HDI) also provides important cumulative components which potential to be used for social vulnerability analysis. For instance, Barnett (2006, P.119),

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[37] "*While Dreze and Sen see entitlements in a wide sense to embrace not only food intake (biology) but access to health care and education (the social environment) - that is to say the broader domain of well-being and advantage - they have less to say about what they call 'capability' and the 'totality of rights' which secure basic needs. In our view entitlements have to be radically extended not simply in a social or class sense but politically and structurally*" (Watts and Bohle, 1993).

[38] Adger and Kelly (1999) points that the assessment of social vulnerability is based on following aspects:

i. *Direct analysis of the material sources of entitlements, which is manifest at the individual level;*
ii. *The distribution of those entitlements at the community or population level; and*
iii. *The institutional context within which the entitlements are formed, contested and distributed over time and among groups*

emphasizes that the Human Development Index (HDI) which is introduced by the UNDP can be considered as one of effective vulnerability analysis indexes as it represents the life expectancy, the level of education attainments, and the income levels (e.g. GDP per capita). Because of, these indicators imply the level of adaptive capacity of communities.

2.2.3. Exposure, coping capacity, adaptive capacity, and resilience of social vulnerability

Perhaps the conceptions of exposure, coping, adaptation, and resilience are complimentary and represent collective idea on social vulnerability. Exposure of livelihood to hazards is an omnipresent in nature of human environment and the degree is varying from place to place. By contrast, the nature of exposure depends upon the characteristics of livelihood and the condition of environment.

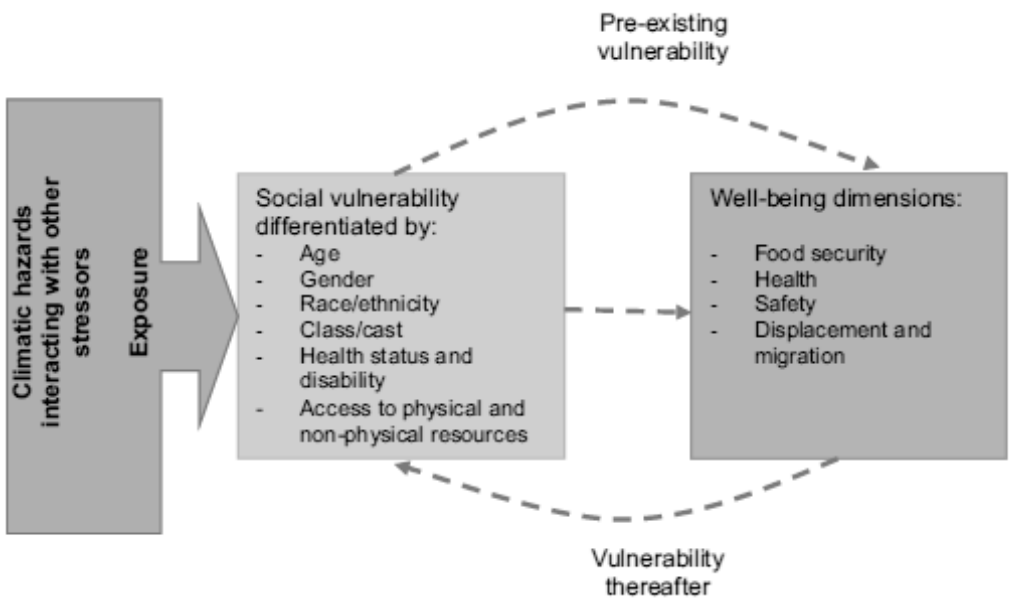

Figure 2.4: The relationship between exposure and vulnerability (Otto, *et al.,* 2017).

Many scholars have been argued that the exposure to risk or stresses is one of the main vulnerability components of livelihood and both exposure and vulnerability have very positive association with one another (e.g. Chambers, 1989; Adger, 1999; Adger, 2006; Jamshed, *et al*., 2019 etc.). Chambers (1989) urged that the vulnerability can be identified as the exposure to unexpected encounters and stresses as vulnerability views for defenselessness, many stresses and exposures to

risks perspectives and therefore difficult to be coped with unexpected disasters or situations. On the other hand, vulnerability is used to define the conception of exposure as it has been associated with the geographical or spatial locations more rigorously compared with the individuals or communities. Therefore, *"exposure is the nature and degree to which a system experiences environmental or socio-political stress"* (e.g. Adger, 1999; Adger, 2006). Similarly, Cutter, Schumann, and Emrich (2014) point that *"exposure approximates the physical impact of the event at each point location"*. Abovementioned insights imply that the locational context also has been related and also influenced to the severity of exposure to vulnerabilities.

Luers and colleagues (2003) proposed an approach to quantifying vulnerability that integrates four essential concepts namely; *"the state of the system relative to a threshold of damage, sensitivity, exposure and adaptive capacity*"[39]. Moreover, Cutter (2017) emphasized that the magnitude of risk of some property as well as croplands for damaging by some disasters is as exposure. Thus the exposure exemplifies that the perspectives of losses including economic base and also their patterns pertaining to localities as well as areas where located in regional contexts. Figure 2.4 depicts that the relationships of exposure and how rest of components are intertwined with each other. Thus, those components are complementary to each other in the context of social vulnerability. By contrast, the level of exposure of a system has been determined by the socio-economic and demographic characteristics in which related to individuals and groups.

Coping capacity implies that the ability of livelihood to stands against the different kinds of disasters and life impediments. Thus, it has been a preeminent exponent of social vulnerability identification among researchers in plenty. Chambers (1989) points an important insight viewing that the coping capacities of poor and marginalized people are solely based on the different characteristics including demographic (e.g. age, gender etc.), economic, and infrastructural facilities. Coping capacity is possible to be eroded with the more economic hardships of livelihood like poverty. In the context of poverty-coping relation, for instance, Neil Adger points that people's strengths to reduce risks and cope with hazards are depending on their poverty status. In contrast, their economic hardships have been effecting to coping and recovery abilities by reducing their resilience capacities (Adger, 1999).

Access to resources is may be the centripetal force with the function of

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[39] Shah (2011, P.111) also views, "*there are still major uncertainties in physical and social vulnerabilities of exposed communities and also, the quality of information about the exposure"*.

institutions in the livelihood coping process. This is because Adger (2006) emphasized that the foremost important aspect for coping with disasters is the distribution and endowment of resources (for example, social and natural resources) and the notion of institutions act as such a negotiator or facilitator for distributing resources and coping practices. De Brito and colleagues (2017) also revealed such similar explanations, stating that the coping capacity is a key component of vulnerability and it determines the abilities of whole communities (e.g. whole system including individuals, groups and others) to cope with disasters and sudden situations by using their resources and proficiencies. Figure 2.5 represents the conceptual interlinks of vulnerability and its components. Adaptive capacity is also a complimentary associate component with the coping capacity which is indicated in the same figure. Regarding the practices of adaptation to disasters, the key component is the capacity of people or systems. Theoretically, the measurement levels of adaptive capacity have been varied upon the abilities (mainly on resources) of individuals and communities (Adger and Vincent, 2005)[40]. Altogether, exposure, susceptibility and coping capacity components are representing by the status of the notion of vulnerability which has interlinked with the poverty and resource endowment (e.g. Adger, 1999; Krellenberg and Welz, 2017). Social system has mainly been linked with the social ties and the organizational infrastructure and those components are foremost important for the society (Queste and Lauwe, 2006, P.109). Thus, if these systems are failed to perform their functions, the direct impacts go to the livelihood and heightened the social vulnerability. By contrast resistance, resilience, and susceptibility account the degree of critical infrastructure vulnerability which effects on the society.

Figure 2.5 implies such a comprehensive associations between hazard, vulnerability, exposure and the risk. On the one hand, hazards are being intertwined with the vulnerability, exposure, and risk in which hazard is not a discursive dimension of the notion of vulnerability. On the other hand, the risk is the function of the cumulative influence of hazard, vulnerability, and the exposure. Therefore, the most important aspect of vulnerability studies is investigation or finding of ways to reduce the risk perception at community level.

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[40] Hence, for example, Zakour and Gillespie (2013, P.60) views that *"community adaptive capacities which focus on resources that have the potential to reduce vulnerability and facilitate resilience"*.

Figure 2.5: Risk, exposure, hazard and vulnerability, the nexuses (Otto, *et al.* 2017).

The risks in which triggered by the disasters have impossible to be stopped. Therefore, practically, social collaborations are pivotal important in the process of reducing risks of disasters. This is because the strengths of social networks in the disaster response and recovery have been proved their abilities in terms of providing a range of reciprocal supports (e.g. Jones and Faas, 2017). On the other hands, the magnitudes of risks has been depend upon the level or density of social ties in which determines by the geographical diversities or spatiality of social networks. For an instance, in accordance with my field works experiences, comparatively dense and resourceful ties are investigated in the regional (rural) areas rather than networks observed in urban informal settlements.

Figure 2.6 clearly depicts the conceptual interactions and associations as direct and indirect flows of ideas which have been shaped the sustainable livelihoods and vulnerability, adaptation, and resilience of human systems. Particularly, the "absence of entitlements" has been made tremendous impacts to the livelihoods as well as to worsen the status of vulnerability. This is because, disaster affected areas where social ties and cohesions are very strong has been filled the vacuum of the absence of entitlements. Therefore, it is noteworthy to be included the notion of the strengths of social ties to the conception of resilience (e.g. in figure 2.6). Importantly, Figure 2.7 exemplifies that the resistance, resistance and susceptibility are depending upon the other factors which they have interlinked with.

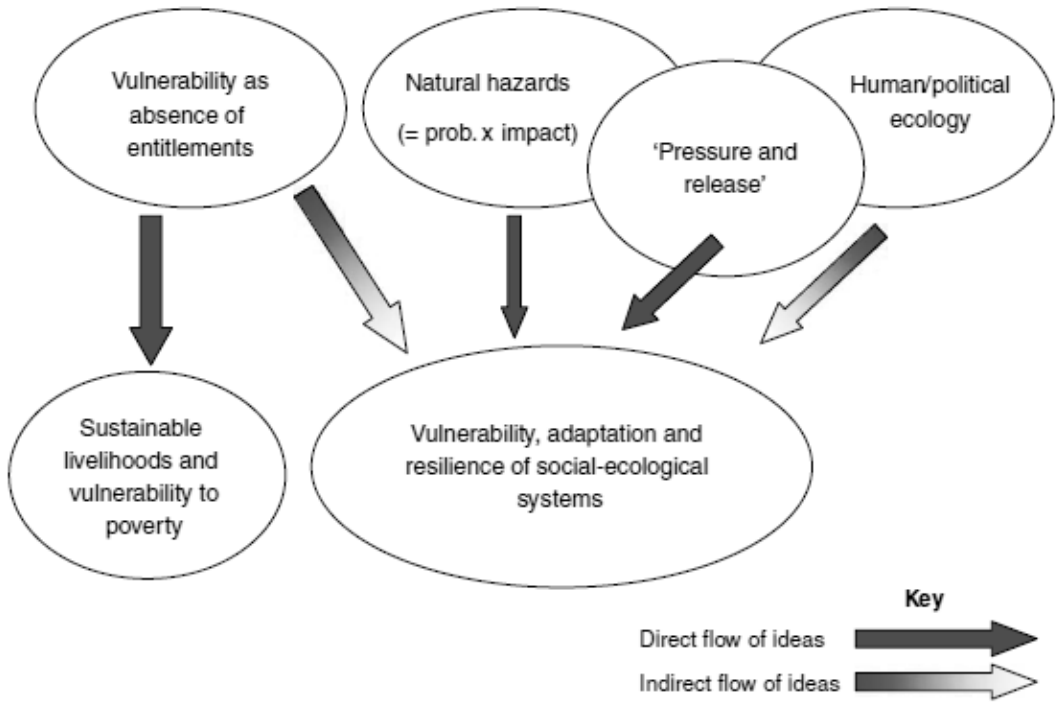

Figure 2.6: Traditions in vulnerability research and their evolution (Adger, 2006).

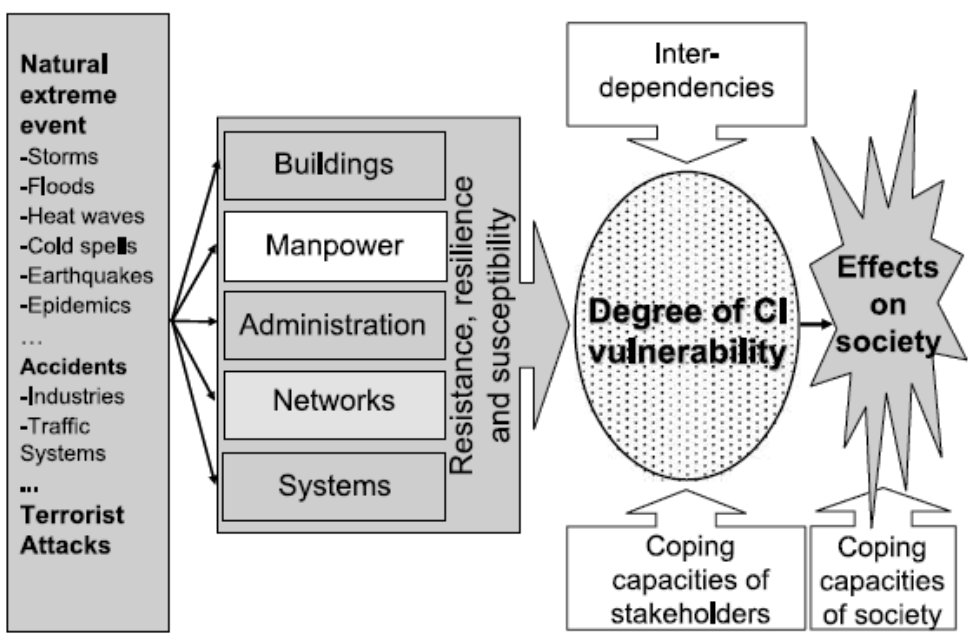

Figure 2.7: The vulnerability of critical infrastructures (CI holistic approach) (Queste and Lauwe, 2006, P.110).

Manpower and networks are very influential proxies among others in determining mainly resilience and susceptibility. In other works, buildings, administration, and systems are secondly important compare to the abilities of networks. The status of these all factors is influenced and determined the degree of vulnerability cumulatively.

The concept of adaptive capacity has also been developed in the domain of the resilience framework, where it is often referred to as "adaptability" to describe the capacity of actors to manage and influence resilience (Fidelman, *et al*., 2017). For Cutter and colleagues (2014), the conception of "community resilience" has been becoming more important, firstly for the disaster response and recovery in "short terms", and secondly, for the adaptation in the climate change scenarios as "longer term" perspectives. This is because the resilience activities have a prowess to withstand against stressors like natural disasters particularly within the context of network communities. By contrast, for example, Cutter (2017), *"the burdens of disasters can be offset by enhancing the resilience of communities"*. Therefore, it is very clear that the ability of resilience in terms of ameliorating deleterious impacts of vulnerability. In other words, the social vulnerability- resilience interaction is very crucial in order to reduce the vulnerability impacts of livelihood. Also, it can be guesstimated that the 'resilience-socio economic network' interaction in terms of ameliorating social vulnerability will be an influential research foci.

2.2.4. Social vulnerability assessment and key applications

A spectrum of applications is visible in the existing body of literature on social vulnerability analysis of different perspectives in plenty. This section will be considered the studies which related to social vulnerability modeling particularly in the context of flooding disasters. In addition, mostly cited models on social vulnerability analysis are discussed. This is because some of applications have been applied the same model in different context of phenomenon. Assessment and mitigation of social vulnerability is very crucial in order to the identification of the influence of causative factors. Due to the multifaceted nature of social vulnerability (e.g. Mavhura, *et al.,* 2017), it has been assessed in different contexts (e.g. Aroca-Jimenez, *et al.*, 2017). According to Dwyer and colleagues (2004), a range of applications have been involved with the measuring of social vulnerability to adverse effects in which lying under the disaster and emergency management literature since 30 years long past. Also, *"since community or social vulnerability is a late arrival, there is the need to develop an agreed methodology or assessment of risk factors"* (Davis, 2004, P.128). Therefore, "*as has long been known, reducing social vulnerability does not depend upon the precision of forecasts of particular*

physical hazards alone" (Pulwarty, *et al.,* 2004, P.83)[41]. "Structural factors" may be influential for the acceleration of social vulnerability. It may be productive to consider structural vulnerability factors for long-term-programs in terms of dealing with socio-economic developments including the advancement of demographic factors (Martínez-Viveros and López-Caloca, 2010, P.264). Regarding the propagandas for reducing social vulnerabilities, private sectors and political circumstances and government circles may have much potential is lining with the social vulnerability assessing alternatives (e.g. Pelling, 2003, P.182; Davis, 2004, P.129). Above insights imply that the social vulnerability is very complex and dynamic[42] phenomenon which warrant that novel application imperatives and overtures.

More importantly, most of the vulnerability applications in extant literature have occupied with both the qualitative and quantitative approaches as the social vulnerability basically linked with the social and demographical factors. Among them, age groups, education, gender, health, well-being, social capital, occupation, income, household status etc. are being considered as predominant indicators. Thesis is because, on the one hand, these factors have been considered to calculate social vulnerability indexes and to map spatially pervasive patterns (Zhang and You, 2014; Antwi, *et al*., 2015; Działek, *et al.*, 2016; Mavhura, *et al.,* 2017). On the other hand, these factors represent the level of social capital in terms of coping capacity, adaptive capacity, and resilience which are preeminent in the ameliorating the social vulnerability (Kita, 2017; Waters and Adger, 2017). Many of studies have revealed that informal settlements for instances, shanties and slums are more vulnerable to natural hazards particularly to the flood hazards in the urban context. In addition, these settlements are very poor in social conditions as they are marginalized in the urban cities. Therefore, people who are living these types of settlements are inherently vulnerable and becoming presumably impasse around the world. Quite different but similar narratives can be found related to rural settlements which are recognized as very poor and unstable households units.

Notably some of studies have applied social network analysis (SNA) in

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[41] Pelling (2003, P.65), urged that *"the responsiveness of individuals and communities to external interventions of this kind is critical if participatory development is to be positive in ameliorating social vulnerability*".

[42] For example, Mavhuraa and colleagues (2017), *"understanding the complexity of vulnerability to disasters, including those triggered by floods, droughts and epidemics is at the heart of disaster risk reduction. Despite its importance in disaster risk reduction, there remains a paucity of approaches that contribute to our understanding of social vulnerability that is hidden in dynamic contextual conditions".*

emergency response (e.g. Malone and Kinnear, 2015; Waters and Adger, 2017; Ceddia, *et al.*, 2017). Despite that they didn't use the networks graphical analysis in order to portray the spatiality of social networks. By contrast, they have used some of descriptive SNA methods to describe the actors' behaviors in emergency situations. Importantly, some of studies have been occupied with the sample based households networks analysis in disaster settings (e.g. Misra, *et al.*, 2017) and also analyzing institutional networks and advancements in flooding events (Htein, Lim, and Zaw, 2017). Very recently, Kim and Hastak (2018) occupied with the social network analysis in order to explore emergency response and revealed that Social networks are actively engaged with the emergency information sharing. In fact, Kim and Hastak's (2018) shows quite impressive application compare to the rest of social network applications. In addition, examine of emergency response networks in Queensland, Australia by Malone Kinnear (2015); evaluating of difference flood risk communication strategies by Haer and colleagues (2016); exploring the determinants and dimensions of adaptive capacity relevant for the lived experience of urban slums by Waters and Adger (2017); assessing of how the implementation of the 'floods directive' has contributed to the level of adaptive capacity in Austria by Ceddia and colleagues'(2017) etc. These applications are implied that the efficacies of social network applications in different emergency perspectives. Despite the facts that these studies have been analyzed the nature of social networks confined to one geographic area. The exact reason may be the practical difficulties of data collections in the variegated geographical settings. Thus, the comparison of the social network behaviors in different geographical settings, for example, urban-rural differences, may help to fill and bridge above gaps. Similarly, another very crucial point is that most of the studies have concentrated to analyze the social vulnerability and other related aspects in to a one particular area or a country or very broader national levels. Thus it is very significant to examine the same context in difference places to understand the exact distinctions in terms of urban-rural or any other meaning as pointed out in the previous paragraph. Thus, this vivid gap is interestingly bridged by present study. On the other hand, the existing methodologies and approaches could be superseded by new approaches and applications.

Moreover, the studies which concerned flood hazards analysis in the social vulnerability context have revealed different narratives in which belonged to different regional settings. For instance, vulnerability manifests itself as a regional phenomenon (Zhang and You, 2014); accessibility to health care found to be severely affected by flooding (Garbutt, *et al.*, 2015); preparedness behavior of communities at risk is influenced by context-specific social and economic factors (Działek, *et al.*, 2016); The social vulnerability is influenced by a variety of

economic, social and institutional factors (Mavhura, *et al.,* 2017); the area built on in flood-prone zones will be significantly higher than today (López-Martínez, *et al.,* 2017). These applications and examined pros and cons help to shape the future directions of the applications on social vulnerability to flood hazards.

Social Vulnerability Index (SoVI®)

Many of researchers who are engaging with the vulnerability studies are often occupied with the SoVI as it has become famous exponent in the social vulnerability analysis. The SoVI was introduced by Susan L. Cutter in 2003. According to Cutter and colleagues' (2003) words, *"county-level social and demographic data were used to construct an index of social vulnerability to environmental hazards, called the Social Vulnerability Index (SoVI) for the United States based on 1990 data"*. They have used 42 independent variables for the data analysis after the normalization process. Also, they have applied PCA which is one of factor analysis method in order to components reduction. They point that, factor analysis allowed them to handle the missing data by substituting zero values for missing data cells and they have calculated the composite social vulnerability index. Also, Cutter (2017) noted that in accordance with the existing body of literature, socio-economic and demographic variables are identified as efficient variables for analyzing the susceptibilities to hazards. This is because, SoVI® recognized as a potential empirical measure of social vulnerability. Another crucial advantage of SoVI® application is that calculated values can be mapped through the spatial unites and displayed the spatial patterns of vulnerabilities and geographical dispersions. Those indications can be used for the planning and mitigations activities especially to identify the areas where immediate considerations and attentions must be paid.

As well, Schmidtlein and colleagues point that the SoVI method is significant algorithm which allowed for quantifying the social vulnerability status beyond a general arithmetic index (Schmidtlein, *et al*., 2008). This is because, SoVI integrates a range of socio-economic , build-environmental, place specific, and even inequalities of individuals and groups of peoples and portrays nationwide image on social vulnerability (Burton and Cutter, 2008; De Loyola Hummell, *et al.,* 2016).

The social vulnerability quantification approach has formulated very clearly by Frazier and colleagues (2014) based on the IPCC framework in their study on Spatially Explicit Resilience-Vulnerability (SERV) model as follows;

$V = [E+S] – AC$

Where, V = vulnerability, E = exposure, S = sensitivity and AC = adaptive capacity, and the conceptual notions of those components are very clearly examined in the section 2.2.3 above. This has again applied as integrated social vulnerability index (ISVI) by Aroca-Jimenez and colleagues in 2017 (Aroca-Jimenez, *et al*., 2017) for the urban applications as follows;

ISVI = E + S – R

Where, E = exposure, S = sensitivity, and R = resilience. The conceptual difference of the meaning between AC and R is quite similar while some of broader aspects are comprised with the R. Perhaps, AC is possible to be considered as one of the main components of R. One of the main drawbacks of this mechanism is the difficulty to integrate with the physical vulnerability aspects of areas which concerned. This may difficult due to the variability of topological components. Schmidtlein and colleagues urged that none of vulnerability studies including can be the original SoVI work (2003), by concerning and analyzing the "sensitivity analysis" regarding the PCA followed approach (Schmidtlein, *et al.*, 2008).

Pressure and Release Model (PAR)

In accordance with the views of Wisner and colleagues, Pressure and Release model (PAR model) is a kind of vulnerability analyzing tool which indicates that how "disaster" happen when the unexpected natural phenomenon (like "natural hazards") adversely affecting the people who are prone to vulnerability (Blaikie, *et al.*, 1994; Wisner, *et al.*, 2004). Their progression of vulnerability may be a function of main three factors namely roots courses, dynamic pressure, and unsafe conditions (figure 2.8). Wisner and colleagues further points that *"the basis for the PAR idea is that a disaster is the intersection of two opposing forces: those processes generating vulnerability on one side, and the natural hazard event (or sometimes a slowly unfolding natural process) on the other. The image resembles a nutcracker, with increasing pressure on people arising from either side – from their vulnerability and from the impact (and severity) of the hazard for those people. The 'release' idea is incorporated to conceptualize the reduction of disaster: to relieve the pressure, vulnerability has to be reduced"* (Wisner, *et al.*, 2004, P.50). The PAR approach is based on the following equation;

Risk = Hazards * Vulnerability

According to Birkmann (2006, P.29), on the one hand the model exemplifies that the process of development of disasters and vulnerability is posing to augment the pressure on people or their system. On the other hand, there are some of

chances to release the pressure from the vulnerable system. And also, for example, Arnall (2015), generally the consequences of natural disaster are solely based on the fundamental conditions of inequality and vulnerability of persons or groups where are located instead of experiencing such a bad even in the beginning. As well, the external structures and the conditions of social collaborations are greatly posed to become such a unexpected event into a physical disaster (e.g. flooding or landslides events). Moreover, the PAR model accounts, for instance, Asgary and Halim (2011), the structural situations and root causative factors such as limiting access to resources and power, socio-economic structures like inequality are historic circumstances and they are making "dynamic pressure" on societies. Similarly, that dynamic pressure has been influenced to create unsafe situations and augment vulnerability. And also this model has been influential as well as pivotal as it covered a range of disaster-vulnerability related principles, especially their causative factors like unsafe conditions, dynamic pressures, and therefore need to release the pressure in order to reduce disaster risks (e.g. Oliver-smith, 2016; Kita, 2017). Particularly lacking of social networks and institutions including religion, income diversifications, failure of government regulations on disaster prevention and mitigation, removing of vegetation covers, governing bodies and systems etc. are main causative factors in which helped to triggered dynamic pressures (e.g. Kita, 2017). On this application background, the social collaborations and particularly the strengths of social networks have been played a pivotal role in reducing dynamic pressures of disaster victims.

Some of insights have been revealed the drawbacks of the PAR model as a metaphor in the social vulnerability analysis context. For example, in the views of Adger (2006), on the one hand even if the PAR model is analyzing the contexts of natural hazards, they may have intentionally ignored the analyzing of 'technological hazards' dimension from the model. On the other hand, as their model comprehensively analyzed the notions of hazards and vulnerability elaborately considering as pressures, the model didn't provide an efficient mechanism to view the broader cause of vulnerability. In addition, similarly, for example, Zakour and Gillespie (2013, P.37), they have given very much attentions to analyze the notions of natural phenomenon driven (e.g. water, earth, wind etc.) natural disasters and they didn't given much concerns to the important notion of 'social processes' in which has been made bib impacts on social vulnerability. They view that the natural environment as inextricably bound with the social, economic, and political environments rather than anthropogenic technical devastations. Amid these critiques, the PAR stands for the analyzing of both the physical enforcements and livelihood dimensions of vulnerability which belongs to the human ecological aspect.

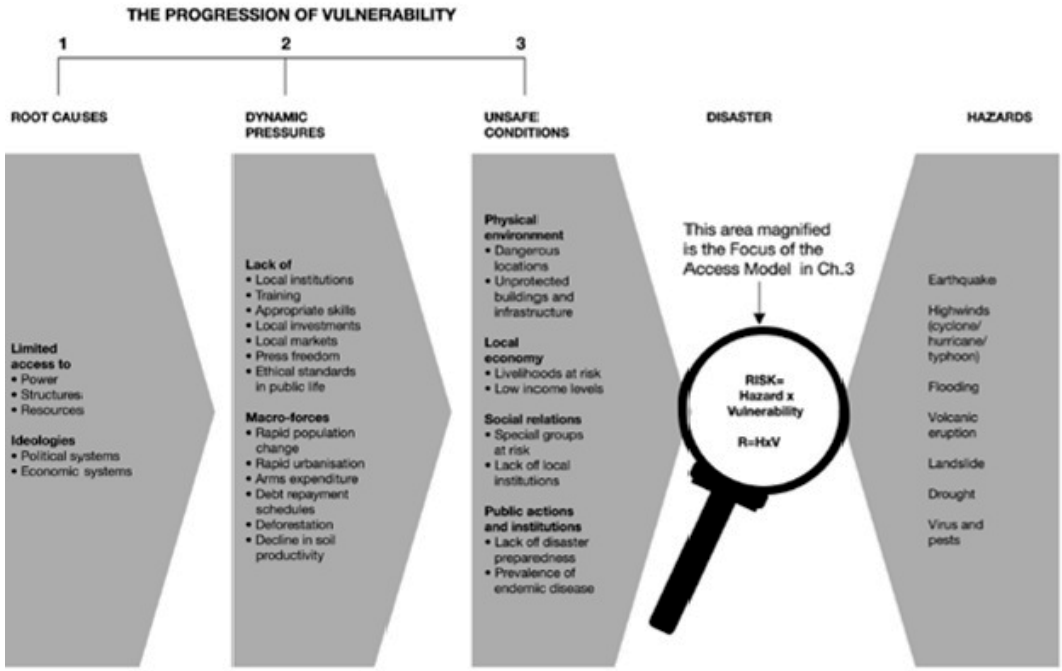

Figure 2.8: The Pressure and Release Model: the progression of Vulnerability (Blaikie, *et al.*, 1994; Wisner, *et al*., 2004, P.51).

Among abovementioned theoretical and applications discussions, some of conceptual and applications considerations are very crucial in the process of identification and analyzing social vulnerability rudiments. Especially, considerations of ideas, for examples, political economy, political ecology, ecological resilience, human ecology, expanded entitlements, and also structuration are very influential as they are engaging with the analyzing of economic inequalities and their causations in the context of disaster risk assessments (e.g. Bogard, 1988; Blaikie, *et al.*, 1994; Bohle, Downing, and Watts, 1994; Eakin & Luers, 2006 etc.). And also, some of disaster resilience models like, place-based model of resilience (e.g. Cutter, *et al.,* 2008) and baseline resilience indicators for communities (BRIC), (e.g. by Cutter, *et al.*, 2014), provides significant examples by developing composite scores and mapping spatial resilience patterns of metro areas. Moreover, world risk report – 2016 (by United Nations University, 2016) has developed a world risk index comprising the components of exposure, vulnerability, susceptibility, lack of coping capacities, and lack of adaptive capacities and classified world countries in accordance with the composite index. Abovementioned conceptual and application contexts provide a broad understanding about the notion of social vulnerability and its behaviors over time and geographical settings.

Chapter 3. Materials and methodologies

This research applied mixed method approach and mainly relied on both quantitative and qualitative data analyzing approaches. This is because the socio-economic networks analyzing, networks graphing, quantifying of social vulnerability including modeling and analyzing, social vulnerability mapping etc. all are related to the quantitative paradigm. The rest of the analyses such as analyzing of social capital context in flood inundation response and recovery, social networks behaviors, social vulnerability characteristics, respondents' expressions, feelings and views, focus groups discussion results and other descriptive aspects all are related with the qualitative paradigm. The study is considered a broader approach to the problem analysis through mixed method application. Figure 1.3 illustrates the methodological framework which has discussed in the each and every section briefly.

3.1. Study areas

In accordance with the theme and objectives of the study, I selected Kuruwita, Elapatha, and Colombo District Secretariat Divisions (DSDs) which are belonged to both rural and urban contexts. Regarding the rural context, Kuruwita and Elapatha DSDs are selected. Both the DSDs are belonged to the Rathnapura district which is one of the famous gem cities in the world, located in Sabaragamuwa province, Sri Lanka. All the sampled Grama Niladari Divisions (GNDs) of Kuruwita DSD (eight in numbers) have been experiencing flood inundations yearly from nearby Kuru River which is one of the main tributaries of Kalu River, Sri Lanka. Similarly, in the Elapatha DSD, seven GNDs are considered for the household survey which is experiencing flood inundations yearly due to the Kalu River which is one of the four main rivers in Sri Lanka. Six GNDs are selected for household survey from the city of Colombo (Colombo DSD) and they are experiencing flooding events from the nearby Kelani River which is also one of the four main rivers in Sri Lanka. The procedure in which used for GNDs selection is explained in the sampling and data collection section. All the DSDs are located in the Wet-Zone of Sri Lanka and have been experiencing heavy rains during the Southwest monsoon period. According to the Department of Meteorology (2019), Southwest monsoon rains are experiencing at any times of the day and night, sometimes intermittently mainly in the Southwestern part of the country. The rainfall intensity during this season varies from about 100 mm to over 3,000 mm (figure 3.1). The places of highest rainfall received in the mid-elevations of the

western slops are Ginigathhena 3,267 mm, Watawala 3,252 mm, Norton 3,121 mm. Thus, all the study areas have often been prone to flood inundation events during this monsoon season.

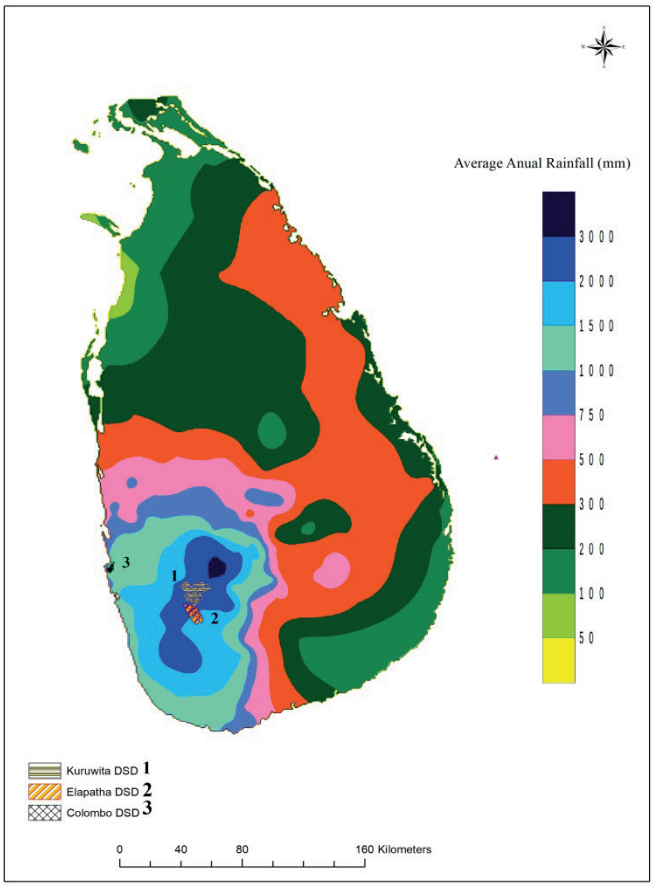

Figure 3.1: Location of study areas within the rainfall zones (Source: Rainfall map: Dept. of Meteorology, 2019).

3.1.1. Kuruwita DSD

Geographically Kuruwita DSD lies between 5°.41′ – 6°.52′ north latitudes and 80°.15′ – 80°.28′ east longitudes. The DSD consists of 39 GNDs and 101 villages within its administrative areas and the current total population is 98, 345. The elevation of the DSD ranges from 1,000 to 3,500 in feet above mean sea level (MSL) (Divisional Secretariat- Kuruwita, 2019). The study identified eight GNDs from the Kuruwita DSD for the household survey which are mostly affected by the 2017 flood inundation in accordance with the data provided by the disaster

management officer, Kuruwuta DSD office. Figure 3.2 shows the relative and absolute locations of selected GNDs and the surveyed households.

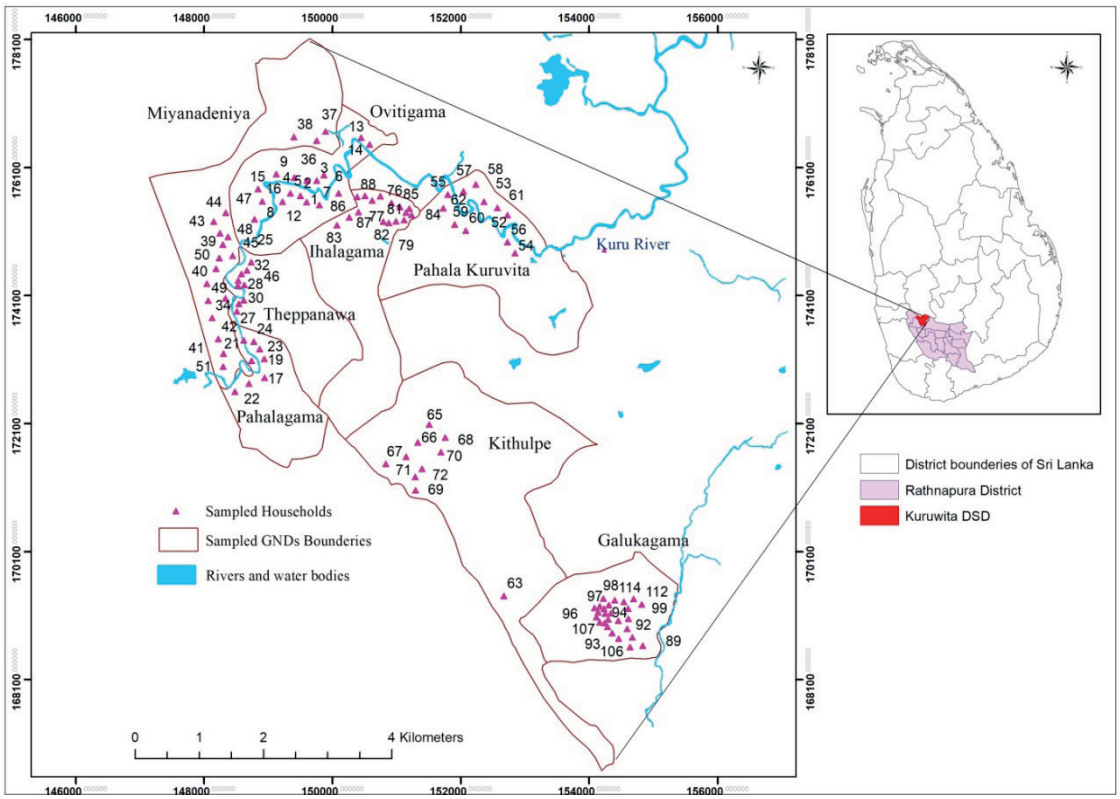

Figure 3.2: Absolute and relative locations of surveyed households and GNDs in Kuruwita DSD

Source: Own cartographic compilation, 2019.

The majority of people who are living in Kuruwita GNDs have been doing agriculture activities mainly tea plantation, paddy cultivation, and rubber plantation. Table 3.1represents the general demographic and socio-economic characteristics of Kuruwita sampled GNDs. Regarding the unemployed status, Ovitigama and Kitule GNDs are representing relative higher percentage (4.24% and 4% respectively, out of total population) and Pahalagama depicts the lower figure (1.81%). And also, Pahalagama and Kitulpe represent higher figures for economically not active people, 36.95% and 35.18% respectively while Ovitigama represents the lowest (25.41%). Galukagama and Pahala Kuruwita are standing for higher values for no schooling, 6.59%, 5.98% respectively and Theppanawa depicts the lowest (2.06%).

Table 3.1: Demographic and socio-economic data of sampled GNDs in Kuruwita DSD

GNDs	Population -2012			Population- 2019***			Socio-economic data –brief -2012			
	Male	Female	Total	male	Female	Total	Em.*	Une.*	Ena.*	Noch**
1. Kitulpe	1,812	1,892	3,704	1871	1912	3783	1,400 (37.8)	148 (4)	1,303 (35.18)	159 (4.29)
2. Ihalagama	1,207	1,273	2,480	1230	1301	2531	987 (39.8)	73 (2.94)	855 (34.48)	136 (5.48)
3.Galukagama	1,182	1,187	2,369	1169	1154	2323	929 (39.21)	57 (2.41)	830 (35.04)	156 (6.59)
4.Theppanawa	1,022	1,018	2,040	1135	1064	2199	830 (40.69)	41 (2.01)	716 (35.1)	42 (2.06)
5. Pahala Kuruwita	1,298	1,295	2,593	1285	1390	2675	1,075 (41.46)	51 (1.97)	864 (33.32)	155 (5.98)
6.Miyanadeniya	906	892	1,798	936	945	1881	764 (42.49)	42 (2.34)	618 (34.37)	44 (2.45)
7. Pahalagama	588	684	1,272	670	711	1381	512 (40.25)	23 (1.81)	470 (36.95)	52 (4.09)
8. Ovitigama	601	556	1,157	559	588	1147	539 (46.59)	49 (4.24)	294 (25.41)	31 (2.68)

Notes:Em.- Employed; Une-Unemployed; Ena.- Economically not active; Noch.- No schooling
-Population aged 15 years and above;- Population aged 5 years and above. All the values in brackets are %.*

Source: Department of census and statistics, 2012; *** Divisional secretariat –Kuruwita, 2019.

On the other hand, Ovitigama exemplifies the higher employed rate (46.59%) while Kitulpe depicts the lowest employed rate (37.8%), out of their total population. Detailed information of socio-economic variables of households have illustrated also in table 3.4, according to the household survey. The average income of households is 24,646 rupees with the minmum of 20, 750 (Miyanadeniya) and maximum of 30, 406 (Ovitigama) (Table 3.4).

3.1.2. Elapatha DSD

Elapatha DSD is geographically situated between 6°.65′ – 6°.72′ northern latitudes and 80°.33′ – 80°.42′ eastern longitudes in Sri Lanka. Elapatha DSD consists of 20 GNDs and total land area is 86.86 square kilometers. The total population of all the 20 GNDs is 41,172 (Divisional secretariat –Elapatha, 2019). It is one of the poorest DSDs in Sri Lanka recorded many years and had been the second poorest DSD in Sri Lanka in the past. In 2002, Elapatha recorded as the poorest DSD in the Sabaragamuwa province[43] with the poverty headcount index of 40.1and the lowest is 6 which is belonged to the Colombo district (Department of census and statistics, 2005). Thousands of poorest people are still living in this area with a range of economic hardships. Selected GNDs are situated very close proximity to Kalu River and some of households are located in the river banks with the distance of approximately 10 to 15 feet surprisingly. Many of them have been involved with the gem mining activities in Kalu River, majority in illegal basis. This is because environmental laws have restricted the digging of river beds and its banks. The relative and absolute locations of surveyed GNDs and households are depicting in Figure 3.3.

According to the table 3.2, the employed percentage (proportionate to the total population) of selected GNDs is ranging from 35.99% (Amuwala) to 39.69% (Kahawatta). Regarding the unemployed status, Raddella represents higher rate (6.51%) and Karangoda depicts the lowest (2.59%) compare to the rest of GNDs. On the other hand, Karangoda presents the highest (39.45%) economically not active rate and Kahawatta exemplified the lowest (31.63%). Generally, all the schooling students are categorized under the economically not active group. Regarding the no schooling rate, Dambuluwana is the highest with 8.01% and Karangoda is the lowest with 3.7%.

[43] One out of the nine administrative provinces in Sri Lanka

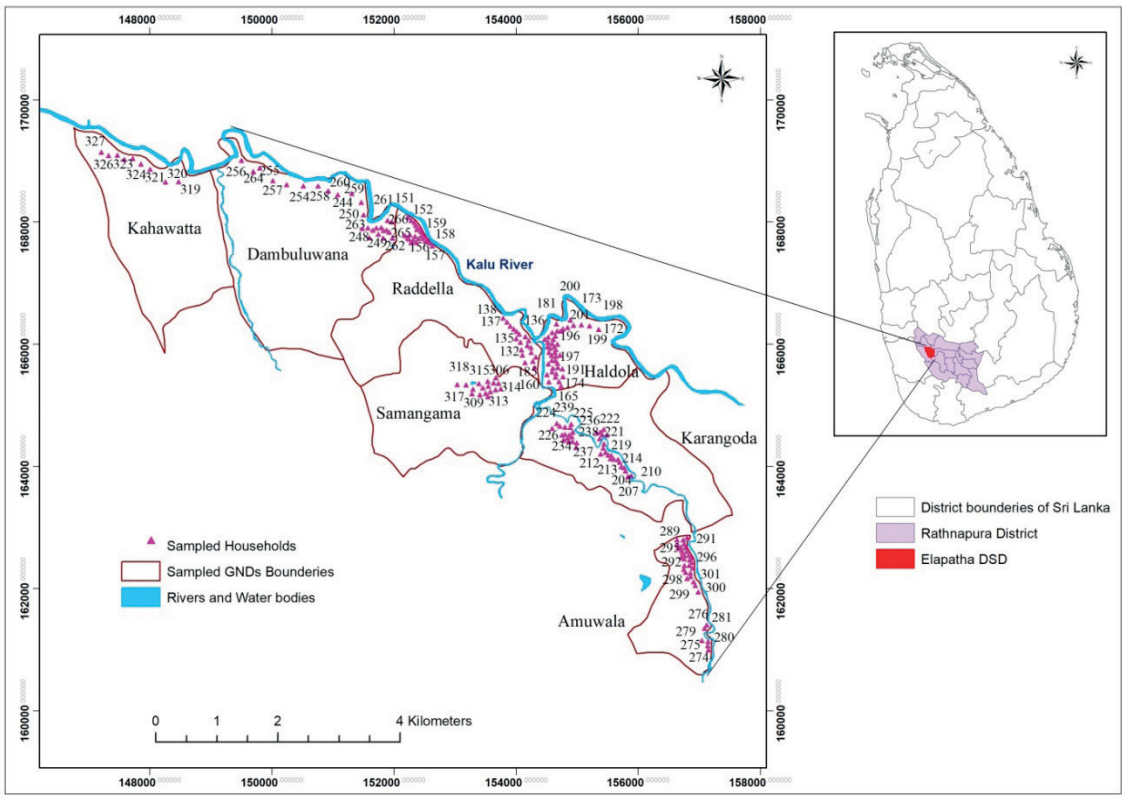

Figure 3.3: Absolute and relative locations of surveyed households and GNDs in Elapatha DSD

Source: Own cartographic compilation, 2019.

Department of census and statistics (2015)[44] revealed that in the years 2012/2013, economically inactive people in Elapatha DSD (in all the GNDs) are 13, 264 and number of poor people are 4,603. Abovementioned figures of employed, unemployed, economically not active, and no schooling are related with the 2012 census and the empirically collected data are representing the current status of those areas. Despite, particularly most of the respondents who are living in Elapatha GNDs are proved that they have no permanent employment and many of them are working as laborers in daily pay basis and also work places are not permanent. Table 3.4 illustrates the selected socio-economic and demographic characteristics of surveyed households. The average household income is 20,079 rupees with the minimum of 15,763 (Dambuluwana) and the maximum of 22,333 (Kahawatta) (table 3.4).

[44] URL: http://www.statistics.gov.lk/poverty/SpatialDistributionOfPoverty2012_13.pdf, (Accessed: 21/10/2017).

Table 3.2: Demographic and socio-economic data of sampled GNDs in Elapatha DSD

GNDs	Population- 2012			Population -2019***			Socio-economic data –brief-2012			
	Male	Female	Total	male	Female	Total	Em.*	Une.*	Ena.*	Noch**
9. Raddella	894	873	1,767	939	932	1,871	645 (36.5)	115 (6.51)	637 (36.05)	75 (4.24)
10. Haldola	1,057	1,047	2,104	1,149	1,110	2,259	793 (37.69)	60 (2.85)	729 (34.65)	82 (3.9)
11. Karangoda	1,142	1,099	2,241	1,160	1,228	2,388	860 (38.38)	58 (2.59)	884 (39.45)	83 (3.7)
12.Dambuluwana	1,007	1,028	2,035	1,055	1,104	2,159	766 (37.64)	67 (3.29)	755 (37.1)	163 (8.01)
13. Amuwala	819	798	1,617	823	838	1,661	582 (35.99)	72 (4.45)	624 (38.59)	72 (4.45)
14. Samangama	985	988	1,973	1,090	1,022	2,112	738 (37.4)	69 (3.5)	686 (34.77)	120 (6.08)
15. Kahawatta	676	677	1,353	716	753	1,469	537 (39.69)	69 (5.1)	428 (31.63)	85 (6.28)

*Notes:Em.- Employed; Une-Unemployed; Ena.- Economically not active; Noch.- No schooling *-Population aged 15 years and above;**- Population aged 5 years and above. All the values in brackets are in %.*

Source: Department of census and statistics, 2012; *** Divisional secretariat –Elapatha, 2019.

3.1.3. Colombo DSD

Geographically the city of Colombo is the largest city of Sri Lanka and is lying between the northern latitudes 6° 51′ - 6° 58′ and eastern longitude 79° 48′ - 79° 55′. Climatically, for example, Perera and Emmanuel (2018), Colombo has been experiencing a warm, humid climate (*"Köppen-Geiger classification = Af − Tropical Rainforest Climate"*), and seasonal differences of temperature and moistures are not found and almost year round rainfall patterns can be found[45]. Also, for example, Lo and Koralegedara (2015), analysis of the future rainfall data of Colombo revealed that many of extreme weather events are possible to be occurred with very heavy rainfall in the coming years. The city of Colombo can be identified as the commercial capital of Sri Lanka and with a range of economic activities, firms, investments, facilities, services, institutions, opportunities are attached. The city is located in the South-western coast of the country (Figure3.4) and the Colombo port is one of the famous ancient ports in South Asian region. Administratively, the city consists of 55 Grama Niladhari Divisions (GNDs) and the land extent of the CMC is about 40 square kilometers. The population density is ranges from 1,097 to 50,859 per square kilometers. The main reason behind this augmentation is internal migration towards the city of Colombo. The city has potentials to be provided job opportunities in particular and this has become main reason behind the development of informal settlements like shanty and slums in plenty. In this context, a plethora of dilemmas are being hybridized in the city of Colombo in terms of pollution, natural hazards and livelihood vulnerability despite is being belonged to the district with lowest poverty headcount index. The port city of Colombo as an Indian Ocean trade city has trade links with Penang and Singapore, Mumbai and Cochin (Amarasuriya and Spencer, 2015). According to Wickramasinghe (2009, P.29), historically, *"the capital city was changing and growing into a more metropolitan space. The expansion of Colombo harbour and the building of a breakwater that was completed in 1884 confirmed Colombo as the major business centre of the island"* (Wickramasinghe, 2009, P.29). The city of Colombo had been attracted among many colonial administrative and many of ruins are exemplifying the historical perspectives of the city (Schut, *et al.*, 2011, P.27). Compare to the primitive epoch, for example, Perera and Emmanuel

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[45] *"Colombo is a lowland region with a typically hot, humid, tropical climate that is affected by seasonal wind reversal of the Asiatic monsoon, which blows from the southwest from late May to late September and from the northeast from late November to mid-February. The temperature and humidity are high throughout the year, creating an uncomfortable thermal environment, which, however, would be worse without the afternoon sea breeze" (Johansson and Emmanuel, 2006).*

(2018), *"Colombo is fast changing in terms of land use patterns, building morphology and population density"*[46]. On the other hand, *"Colombo has grown in the years since independence, but it remains well short of anything like a stereotypical Asian megacity"* (Amarasuriya and Spencer, 2015). It is very impressive add some of historical flood experiences in the city of Colombo and its surroundings. For instance, Burton, Kates, and White (1993, P.75) pointed out that *"at least 135,000 city dwellers were displaced in Colombo by a flood in 1947…"*. The city of Colombo as well as the nearby Kelaniya and Peliyagoda cities are located in flood plains and are experiencing with large industrial installations (Burton, Kates and White, 1993, P.75). These historical backgrounds have been brought the city of Colombo to the fore particularly in terms of as the economic hub of the country.

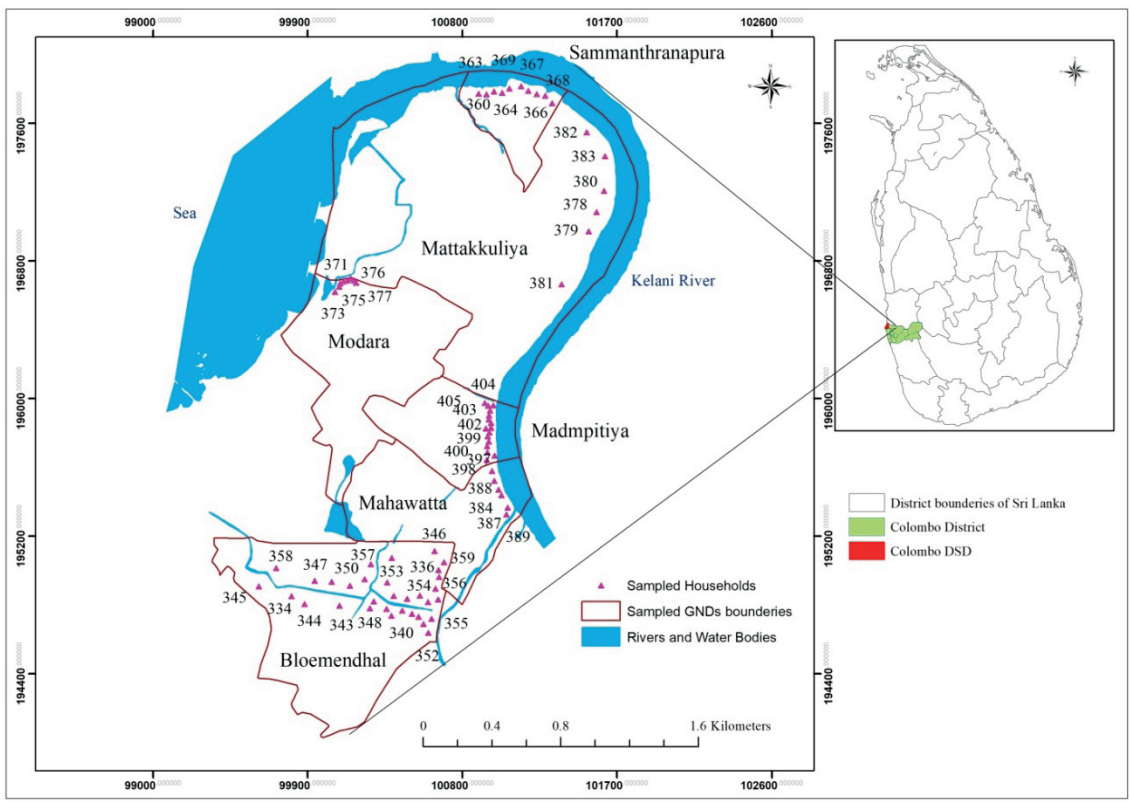

Figure 3.4: Absolute and relative locations of surveyed households and GNDs in Colombo DSD

Source: Own cartographic compilation, 2019.

[46] *"The World Bank is one of the main sources of funding for the Metro Colombo Urban Development Project and the associated Green Growth Programme"* (Amarasuriya and Spencer, 2015).

Compared to the rural areas, Colombo DSD accounted for highly scattered population within a limited land extent. Therefore, ranges of complex problems are existing in terms of environmental and socio-economic issues. The main reason behind the severity of socio-economic problems is may be the dissimilar income distribution patterns. This is because, main poverty indexes (e.g. poverty headcount index), are comparatively very low in Colombo district. Nevertheless, poorest of the poor people are found during the household survey and field visits particularly in the informal settlement areas. According to the department of census and statistics of Sri Lanka (2017), the Gini coefficient of urban sector regarding the households income is 0.48 while rural and state sectors are representing 0.44, 0.36 respectively (the national level is 0.45). These figures implied that the inequality of income distribution particularly in the urban sector compared to the rural and state sectors. The same report revealed that the household monthly mean per capita income has increased by 39%, from Rs. 11,819 (in 2012/13) to Rs.16,377 in 2016 (urban, rural and state sectors account Rs. 22,297, 15,508, and 8,566 respectively). During the same period of time, monthly real mean household expenditure has increased from Rs. 31,331 to Rs. 38,282. In accordance with the abovementioned figures, there is a crucial gap between mean household income and the mean household expenditures. Of course, in accordance with the empirical data (e.g. table 3.4), the average household income is 10,194 rupees with the minimum of 8,833 (Mattakkuliya) and the maximum of 10, 872 (Bleomendhal). It is important to mention that the survey results are related to the households which are situated in informal settlements. Nevertheless, differences are solely depends on the sample sizes.

According to the table 3.3, employed population as a proportion of total population is ranging from 33.6% (Modara) to 36.3% (Sammanthranapura). Regarding the unemployed rate, the lowest rate is 1.7% (Madampitiya, Mattakkuliya) and Bloemendal, Mahawatta, and Sammanthranapura represent the highest (1.9%). These figures are quite low compare to the rural GNDs. Economically not active rates are ranging from 31.3% (Madampitiya) to 39.7% (Modara). The lowest no schooling rate accounts in Modara (3.4%) while the highest depicts in Madampitiya (8.9%). Generally, Sri Lanka is as a developing country has been experiencing quite high human development achievements among the rest of developing nations (Karunarathne & Andriesse, 2018). However, there are some of spatial deviations of socio-economic indicators possible to be found among different study regions.

Table 3.3: Demographic and socio-economic data of sampled GNDs in Colombo DSD

GNDs	Population -2012			Population- 2019***			Socio-economic data –brief -2012			
	Male	Female	Total	male	Female	Total	Em.*	Une.*	Ena.*	Noch**
16.Bluemendal	6,740	7,062	13,802	7,013	7,348	14,361	4,755 (34.5)	261 (1.9)	5,377 (39.0)	552 (4.0)
17.Madampitiya	6,505	4,465	12,970	6,769	6,727	13,496	4,639 (35.8)	219 (1.7)	4,062 (31.3)	1,156 (8.9)
18.Mahawaththa	4,367	4,442	8,809	4,544	4,622	9,166	3,185 (36.2)	167 (1.9)	3,195 (36.3)	638 (7.2)
19.Sammanthranapura	4,017	3,812	7,829	4,180	3,966	8,146	2,844 (36.3)	149 (1.9)	2,487 (31.8)	611 (7.8)
20.Mattakkuliya	14,029	13,974	28,003	14,598	14,540	29,138	9,672 (34.5)	466 (1.7)	10,599 (37.8)	1,075 (3.8)
21.Modara	8,794	8,963	17,757	9,151	9,326	18,477	5,964 (33.6)	327 (1.8)	7,044 (39.7)	612 (3.4)

*Notes: Em.-Employed; Une-Unemployed; Ena.- Economically not active; Noch.- No schooling *-Population aged 15 years and above;**- Population aged 5 years and above. All the values in brackets are in %.*

Source: Department of census and statistics, 2012; *** Divisional secretariat –Colombo, 2019.

Table 3.4: Socio-economic and demographic characteristics (selected) of surveyed households (n = 405) / Source: Own household survey, 2018/2019.

GNDs (1-8 =Kuruwita DSD) (9-15 =Elapatha DSD) (16-21 =Colombo DSD) (* Urban GNDs)	Age groups (years) / frequency					Gender		Marital status			Education levels				Economic and other indicators			
	< 15	16-30	31-45	46-65	> 66	Male	Female	Married	Single	Widowed or divorced	No schooling*	Primary	Secondary	Degree or above	Average household income	# of unemployed	Dependency ratio	# of Ill or disabled
1.Kitulpe	10	14	8	11	7	25	25	34	16	0	10	11	28	1	26,450	22	0.78	14
2.Ihalagama	12	24	7	20	3	34	32	34	30	2	2	8	54	2	23,031	11	0.51	18
3.Galukagama	25	25	23	21	7	48	53	56	43	2	18	18	65	0	20,808	32	0.48	20
4.Theppanawa	12	4	8	10	4	17	21	24	13	1	4	4	30	0	26,667	15	0.66	9
5.Pahala Kuruwita	11	12	12	8	3	19	27	22	23	1	2	6	37	1	23,182	14	0.31	9
6.Miyanadeniya	16	12	15	14	10	36	31	37	28	2	1	16	42	8	20,750	21	0.59	18
7.Pahalagama	5	9	8	9	1	16	16	21	11	0	4	5	22	1	25,875	9	0.21	2
8.Ovitigama	12	18	8	22	3	32	31	41	21	1	6	14	40	3	30,406	16	0.43	13
Average (Kuruwita DSD)	**13**	**15**	**11**	**14**	**5**	**28**	**30**	**34**	**23**	**1**	**6**	**10**	**40**	**2**	**24,646**	**18**	**0.50**	**13**
9.Raddella	38	53	31	47	17	91	95	107	75	4	21	35	125	5	22,100	63	0.51	48
10.Haldola	40	51	38	25	10	80	84	87	74	3	15	28	118	3	18,607	43	0.43	41
11.Karangoda	31	32	32	28	11	74	60	75	56	3	10	17	101	6	20,229	36	0.51	29
12.Dambuluwana	21	28	25	20	7	56	45	56	43	2	17	22	61	1	15,763	52	0.35	22
13.Amuwala	21	42	24	44	7	72	66	83	52	3	13	25	90	10	20,531	40	0.32	29
14.Samangama	16	21	14	14	12	39	38	48	27	2	10	14	51	2	20,988	32	0.81	17
15.Kahawatta	10	9	9	7	3	17	21	19	18	1	3	3	32	0	22,333	11	0.47	8
Average (Elapatha DSD)	**25**	**34**	**25**	**26**	**10**	**61**	**58**	**68**	**49**	**3**	**13**	**21**	**83**	**4**	**20,079**	**40**	**0.49**	**28**
16.Bluomendal *	10	28	20	25	5	41	47	64	17	7	16	28	44	0	10,872	27	0.20	21
17.Madampitiya *	4	14	7	8	1	19	15	22	10	2	7	11	16	0	10,344	14	0.30	5
18.Mahawaththa *	4	4	5	4	1	8	10	9	7	2	2	8	8	0	12,917	9	0.53	3
19.Sammanthranapura*	5	3	6	7	3	11	13	14	6	4	6	8	10	0	8,950	13	0.25	7
20.Mattakkuliya*	5	5	2	4	0	7	9	10	5	1	5	4	7	0	8,833	6	0.39	3
21.Modara *	6	7	3	5	0	10	11	11	7	3	6	9	6	0	9,250	12	0.35	6
Urban Average/Colombo	**6**	**10**	**7**	**9**	**2**	**16**	**18**	**22**	**9**	**3**	**7**	**11**	**15**	**0**	**10,194**	**14**	**0.34**	**8**
Rural Average	**19**	**25**	**18**	**20**	**8**	**45**	**44**	**51**	**36**	**2**	**10**	**16**	**62**	**3**	**22,363**	**29**	**0.50**	**21**

Table 3.5: Flood inundation depths and durations of flood related to surveyed households (n = 405).

GNDs (* Urban GNDs)	Duration of inundation (days) /mean	Inundation depth (feet) *				
		Mean	Minimum	Maximum	Std. Deviation	Variance
1.Kitulpe	4.3	6.9	3	18	4.43	19.66
2.Ihalagama	3.9	5.06	3	9	1.61	2.6
3.Galukagama	4.0	6.12	2	17	3.53	12.43
4.Theppanawa	6.9	9.22	5	15	3.34	11.19
5.Pahala Kuruwita	2.6	3.45	2	6	1.44	2.07
6.Miyanadeniya	3.9	5.67	3	10	1.97	3.88
7.Pahalagama	6.6	9.63	5	12	2.50	6.27
8.Owitigama	6.7	8.13	4	14	2.53	6.38
Kuruwita Average	**4.9**	**6.77**	**3.38**	**12.63**	**2.67**	**8.06**
9.Raddella	8.7	15.0	4	23	5.43	29.5
10.Haldola	7.4	13.26	4	25	4.81	23.17
11.Karangoda	6.3	11.87	2	26	5.65	31.9
12.Dambuluwana	5.9	12.52	2	21	6.03	36.41
13.Amuwala	4.7	8.46	5	13	2.29	5.26
14. Samangama	4.5	6.65	2	15	3.76	14.12
15.Kahawatta	7.8	12.11	4	20	5.71	32.61
Elapatha average	**6.5**	**11.41**	**3.29**	**20.43**	**4.81**	**24.71**
16. Bloumendhal *	2.1	3.38	2	4	0.66	0.44
17. Madampitiya *	1.8	3.1	3	4	0.25	0.63
18. Mahawaththa *	1.2	2.83	2	4	0.75	0.57
19. Sammanthranapura*	2.0	3.2	3	4	0.42	0.18
20. Mattakkuliya *	1.0	2.83	2	3	0.41	0.17
21. Modara *	2.0	3	3	3	0.00	0.00
Average /urban/Colombo	**1.7**	**3.06**	**2.50**	**3.67**	**0.42**	**0.33**
Average / rural	**5.7**	**9.09**	**3.33**	**16.53**	**3.74**	**16.39**

Source: Own household survey, 2018/2019. *Notes: 1 – 8, Kuruwita DSD; 9-15, Elapatha DSD;16 -21, Colombo DSD.*

3.2. Research methods and empirical applications

This study is mainly relied on the mixed method research approach[47], which comprises both the quantitative and qualitative research approaches (Bryman, 2012, P. 160, P. 379) as this study shedding the lights on social networks analysis and social flood vulnerability investigation. The mixed method approach has widely been applied by the scholars as the method allowes to be engaged with both quantitative and qualitative approaches on empirical data in which collected from the variegated geographical and socio-economic settings (e.g. Wang, *et al*., 2016; Zhang & Shin, 2015; Eugenia Ng, 2014 etc.). Some of data collection method for example focus group interviews allow researcher to collect more diverse and collaborative information, sometimes do not covered by the personal interviews like questionnaire survey and occupied with both or more techniques (e.g. Wang, *et al*., 2016; Eugenia Ng, 2014). The mixed approach has been becoming "more common requirement" for studies as it stands for such an integrated approach in terms of having more advantages (e.g. Bickman & Rog, 2009). On this context, I selected the mixed method approach as an appropriate research method for my study.

3.2.1. Data collection

The study is used both the primary and secondary data for the fulfillment of the requirement of study's objectives. Also, the major analysis of study relies on the primary data in which collected from all study areas (Kuruwita, Elapatha, and Colombo DSDs) during thirteen months from January, 2018 to January, 2019.

Selection of study areas and empirical data collection

The study areas (e.g. sampled GNDs) were selected in accordance with the numbers of mostly affected households (this was obtained from the disaster management officers in the respective Kuruwita, Elapatha, and Colombo DSDs) by adverse flooding events which were occurred during 2016 and 2017 years (related to the overflows of Kalu, Kuru, and Kelani Rivers). In some of cases, the numbers

[47] *"The term mixed methods research is used as a simple shorthand to stand for research that integrates quantitative and qualitative research with a single project. 'Mixed method research' has increasingly become the proffered term and in many ways better expresses the fact that, in many cases, using both quantitative and qualitative research should involved a mixing of the research methods involved and not just using them in tandem" (Bryman, 2012, P. 628).*

of affected households were revised in accordance with the updated detailed provided by the relevant Grama Niladari Officers (GNOs). Table 3.6 depicts the numbers of affected HHs in details.

The household survey was conducted at two phases. Phase one involved with primary field observations and identification of appropriate households (HHs) for data collection during first month. During this period, randomly selected HHs respondents (e.g. around ten respondents) were interviewed (e.g. as pilot tests) in order to check the suitability and effectiveness of prepared questionnaire, its open ended and close ended questions, time duration etc. Following this process, some of questions and their structures were changed. In the second phase, I involved with the questionnaire survey, focus group discussions, informal interviews and self-observations that is during the second to thirteen months. It was almost hard task to collect socio-economic network data which with related to three stages (before, during, and after) on flood inundation events particularly in urban informal settlements during my research course.

Sampling method and sample size selection procedure

According to a famous sampling calculation model called Raosoft (2004)[48], with 95% confidence level and 5% margin of error (5% is a common choice), sample sizes were calculated for both rural and urban study areas. Raosoft sample size calculator is very famous among social science researchers who are based upon primary data collection and it calculates a sample size and margin of error, with detailed interpretations of the statistics and the underlying algorithm and also it runs under Java Scripts. The number of HHs in which attached to each and every GND are calculated based on the proportionate to the total affected HHs of each DSD with the consideration of Raosoft values obtained for both the sectors(see Table 3.6). Then, all the sampled HHs are selected in accordance with the simple random sampling method from the lists of mostly inundated households that prepared after the discussion with DSDs' disaster management officials and GNOs (e.g. *Sampling Frame*, is based on stratified sampling method*)*. As the random sampling is a probabilistic sampling method, each and every observation unit of the considered population has an equal chance to be selected to the sample (Bryman, 2012, P.190). Altogether, 405 HHs covering 21 flood-affected GNDs (327 and 78 HHs which attached to rural and urban sectors, respectively) are considered for

[48] Raosoft Sampling (2004), Sample size calculator, URL: http://www.raosoft.com/samplesize.html, (accessed: 29/10/2017).

primary data collection (table 3.6).

Table 3.6: Procedure adapted for the sample size determination

GNDs	Affected HHs	Sample sizes for sectors (Raosoft calculation*)	Proportional sample sizes for GNDs	Sampled HHs / response rates (%)
1. Kitulpe	66	**327**	10	10 (100)
2. Ihalagama	105		16	16 (100)
3.Galukagama	170		26	26 (100)
4.Theppanawa	60		9	9 (100)
5. Pahala Kuruwita	75		11	11(100)
6.Miyanadeniya	120		18	18 (100)
7. Pahalagama	50		8	8 (100)
8. Ovitigama	109		16	16 (100)
9. Raddella	300		45	45 (100)
10. Haldola	280		42	42 (100)
11. Karangoda	250		38	38 (100)
12.Dambuluwana	175		27	27 (100)
13. Amuwala	230		35	35 (100)
14. Samangama	114		17	17 (100)
15. Kahawatta	60		9	9 (100)
Total of the Rural sector	**2,164**		**327**	**327 (100)**
16. Bloemendal	740	**311**	142	32 (22.5)
17. Madampitiya	310		60	16 (26.7)
18. Mahawaththa	117		23	06 (26.1)
19. Sammanthranapura	202		39	10 (25.4)
20. Mattakkuliya	111		21	06 (28.6)
21. Modara	136		26	08 (30.7)
Total of the Urban sector / Colombo	**1,616**		**311**	**78 (25.1)**
Total (Rural, Urban)	**3,780**	**638**	**638**	**405**

Notes: : 1 – 8, Kuruwita DSD; 9-15, Elapatha DSD;16 -21, Colombo DSD.

* *http://www.raosoft.com/samplesize.html*

Source: Own compilation, (2018)

During the household survey, 47 elderly people (who are living in the rural sector) were separately interviewed (age >75 years; for male, n = 31), in accordance with the snowball sampling method in order to collect the past memories of flood inundation events. Snowball sampling method is one of the non-probabilistic and popular sampling methods (e.g. Bryman, 2012, P. 202). I contacted all the elderly people in accordance with the information provided by

inundated householders and followed by the unstructured interviews. Regarding urban informal settlements, none of appropriate elderly personals found as they are not permanent residence of that areas.

It is very general that with the increasing of target population (e.g. flood inundated HHs), the sample size does not increased exponentially (e.g. Raosoft, 2004). Therefore, even in the cases with quite large differences of target populations indicate small differences of sample sizes. The response rate for rural sectors was 100% and for the urban sector was 25.1%. Frankly speaking, data collection course in the informal urban HHs was almost very hard and majority of them refused to participate for the interviews saying that many of officials coming to collect their information but they didn't take any mitigation measures to solve their problems and didn't receive nothing from them etc. On the contrary, the entire rural HHs were agreed to participate for the interviews and provided their information more helpfully. Especially, on the one hand, I personally have relational ties with villagers in my nearby hometown areas and on the other hand, villagers often believe that there may be some possible opportunities to receive some benefits from these kinds of data collection, even after I explained my study intention and goals.

Primary data collection tools

The main primary data collection tool of my research is the questionnaire survey (or survey questionnaire) in which conducted during thirteen months of period from January, 2018 to January, 2019 in order to cover all the required data need including basics HHs information and their facilities, demographic information, basic infrastructure facilities of survey areas, HHs flood inundation records and information, flood evaluation information, collaboration, their feelings and satisfactions, network information, and social capital information (see Appendix 9). In contrast, all the quantitative and qualitative information were covered mainly by the questionnaire survey (in accordance with the research objectives and research questions of the study) in addition to focus group interviews. The questionnaire consists of mainly open-ended, closed-ended (pre-coded), and also multiple choices (which is in the Likert scale) questions. The questionnaire survey was conducted and administrated by the local Sinhalese language and information filled with both Sinhalese and English languages. Four research assistants (graduates) were occupied as supporters and three (with myself) were engaged with recording information in the questionnaires. Tape recordings also were used in some of cases with the consent of respondents. The average time duration per questionnaire (one HHs) was ranged from 50 minutes to one hour and

in some cases more than one hour. Altogether 405 questionnaires were occupied covering all the 21 GNDs as described in the sample selection section in detail.

Theoretically, questionnaire has a range of questions (this is depend on the research purposes) in order to capture respondents' answers. Whether the respondents' information and views are true or false, generally researchers accept them as true information without making criticisms as that is not the primary concern (Montello and Sutton, 2006, P.88). However, researcher's background knowledge and experiences about study areas may shape the reliability of information. For an instance, in order to identify socio-economic network behaviors of flood inundation events, personal experiences of researcher may be more instrumental. And also, separate field notes were maintained during the questionnaire survey and the additional information of field notes are very crucial in the clarification of investigations. Also the study occupied with ten pocus group interviews in addition to household survey. This method is very crucial to collect information on their collective efforts before, during, and after flooding events and particularly to understand their feelings and views on supportive socio-economic networks. Generally, focus groups as unstructured interviews can be conducted with few (three or four) to many (about fifteen to twenty) participants which are very helpful for gathering further information and clarifying them (Montello and Sutton, 2006, P.88). Moreover, their arguments, the language in which they used during the discussions are very significant features and on the other hand, many groups may lead to the complexity of analysis of information (e.g. Bryman, 2012, P. 505). Unstructured interviews were conducted with the relevant GNOs and some of disaster management officials of DSD offices regarding the process of flood inundation events. More importantly, personal field observations and experiences during past flooding events were very helpful for better understanding and analyzing the course of my research.

Regarding the network data collection, three separate cross-tabulations are used in the same questionnaire and interviewees (head of HHs or representative, only those who have experienced at immediate past flood inundation events) were asked to list the most helpful (influential) supporters or organizations (up to 12 names, from A to L) at before, during, and after the flood inundation (see, Appendix 9). The before flood inundation phase is related to during torrential raining and the beginning of overflow the nearby rivers. After HHs obtain clear evidences of sudden flooding, some of them begin to move out, that is the before phase. The during phase is after began the flood inundation of their premises and dwelling units. This phase is strengthening over the total inundated period/duration. In some villages, it took more than two weeks. After the river became the normal rhythm of its flowing, the after phase began. Supporters' particulars and

information are collected in the same tabulations (including the length of relationships, types of relationships, place of residence, and types of helps received etc.). Much concern was drawn to the network data collection related to three phases of flood inundation. The time duration of three phases covers the entire duration of flooding event (from preparation to re-establishing of livelihood), in some cases (rural villages), it lengthier than 15 days. The supportive actors' names and their particulars listed in accordance with respondents' memories based upon personal network research design which is solely considered on ego-networks procedure (e.g. Borgatti, Everett, and Johnson, 2013, P. 262; Jones and Faas, 2017). Their memories are believable and reasonable as majority of their supporters are relatives, neighbors, and friends (e.g. following with name generators, name interpreter, and name interrelator procedures). Also, in almost all the HHs, other members supported to interviewee to explain their experiences. GNOs also explained their overall memories on supportive networks. I followed the similar ways of network data collection in which used by some of social network studies in disaster contexts (e.g Baird and Gray, 2014; Meyer, 2017). Some of studies have considered many years for network data collection. More importantly, regarding the evolutions of social networks, Osbahr and colleagues (2008) pointed that they have found, social networks of their study area have evolved and changed over past 20 years. Furthermore, a range of impediments were faced during the primary data collection course and mainly, many of respondents tried to force me to select their relatives and friends' HHs for data collection as they are believing something (money or material helps) will possible to be received by my research despite even after I explained my research purpose. Permission for data collection was sought from related DSD offices and also obtained the consent from each HHs prior to interview them.

It is obvious that managing such a large HHs dataset (with their actors) in which related to three phases of time in social network analysis is quite hard task. In accordance with the existing body of literature, some social network studies have occupied with large HHs samples. For example, Waters and Edger (2017) have considered 720 households for their urban resilience study. Marcum, Wilkinson, and Koehly's (2017, P.118) personal networks study on hurricane IKE was interviewed 497 persons related to 162 families. Stevenson and Conradson's (2017, P.165) study on organizational support networks after the Canterbury earthquake (2010/11) has occupied with a quite larger sample of 366. Baird and Gray's (2014) study conducted semi-structured interviews with 64 participants on social network transition. And also, Misra and Colleagues's (2017) study on social networks response to cyclone Aila, has collected data from 33 households in which related to five conceptual phases. On this context, 405 HHs are exemplified a

broader sense to theorization of the conception of socio-economic networks' prowess in the ameliorating social vulnerability to flood inundation, in the Sri Lankan disaster mitigation discourse.

Secondary data sources

Secondary data are collected from different sources as represents in the table 3.7 and most of the secondary data sources are from the government agencies. A growing numbers of recent social network studies have been occupied with the secondary data from the ways in which collected by national enumeration censuses. Nevertheless, it is more important to engage with the empirical data in terms of examining and analyzing ground truths.

Table 3.7: Secondary data sources

Data types	Institutions	Year(s)
Maps and layers (Admin boundaries, topology, river networks etc.)	Department of survey, Sri Lanka	2003
Basics socio-economic data	Department of census and statistics, Sri Lanka	2018/2019
Basic population and demographic data	Department of census and statistics, Sri Lanka	2018/2019
Floods events and affected household data	Ministry of disaster management	2016/2017
Technical Reports, archives, news papers, policy papers, other written documents	Particularly from the government departments and ministries	2014/2015/2016 /2017/2018/2019
Flood inundation data and latest population data	From relevant DSDs	2017
Basic meteorological data	Department of Meteorology, Sri Lanka	2017/2018

Database management and manipulation

Data entering and feeding were commenced during the data collection simultaneously as it helped to identify the incomplete data and for detecting data inconsistencies. It is obvious that there could be sometimes considerable differences between raw data and refined data. Therefore I used Microsoft Access package (2010) for the data entering. I prepared questionnaire format in the Access Forms for entering row data and that procedure allowed me to reduce the data entry errors. And also, it is very convenience to recall entered data through the IDs (e.g. primary key) of observation units (e.g. HHs) and check the contingency of data miss-feeding errors. Finally, Access database was converted into the Statistical Package for Social Sciences (SPSS) version 23 (IBM, 2015). Frequency tables are used to identify missing data and for data screening. I coded missing data using the code 99 (as missing 'Age' data are not existed) and also I didn't occupy with data imputations as all the key data and related information gathered more carefully. On the other hand, a separate database (using Microsoft Excel – 2010) was created and maintained for the network data manipulation. This is because, network data were collected using a specific cross-tabulation format (appendix 9) and Excel is more convenience for handling network data with the UCINET platform (version 6.679). In the process of making adjacency matrixes, I occupied with the binary measurement (e.g. 1 entered if a relationship/help occurred and 0 used for otherwise) under one-mode network approach (e.g. rows and columns counts are equal) in which identified as most common matrix approach and have been applied in a plethora of SNA studies. ArcGIS 10.3.1(ESRI, 2015) is used for the spatial data management such as for conducting all the mapping and cartographic works.

3.2.2. Quantitative and qualitative analysis methods and measures

This study has applied different methodologies in which related with both the social network analysis and social vulnerability analysis in accordance with the study objectives. Firstly, regarding the social network analysis, I explained the basic formulations here in which applied for the network characteristics measurement (e.g. degree, closeness, and betweenness centralities, effective size, etc.). Secondly, I explained the procedures which I used for the analysis of social vulnerability to flood inundation. Finally, some of mapping methods the ways in which used for mapping purposes are explained.

Social network measures

In order to identify the socio-economic network behaviors at before, during, and after the flood inundation phases, study occupied with several network measures. Socio-economic networks analysis and mapping of flooding events can be identified as such a big challenge compares to the rest of networks topologies due to its complexity [49]. Following formulations are based on the network measurement measures.

Degree centrality can be identified as one of the influential measures of social network analysis (SNA) as it represents the number of links which with actors are involved. This is because, the number of connections is the most influential factor for the determining actors' positions in their networks and for the information access (e.g. Newman, 2010, P. 169). In contrast, the degree centrality is determined by the in-degree and out-degree centralizations of actors (e.g. Kim and Hastak, 2018). Therefore the most active actor(s) of networks (indicating the most ties) could have maximal degree density values (e.g. Wasserman and Faust, 1994, P.178). This study used degree centrality (almost degree density), closeness centrality, and betweenness centrality analysis in order to identify the effectiveness of socio-economic networks in terms of risk communications, a range of helping activities, resource provisions, evacuating etc. The degree centrality can be calculated using the following formulation (e.g. Borgatti, Everett, and Johnson, 2013, P. 165).

$$d_i = \sum_j x_{ij} \qquad (1)$$

Where, d_i depicts the degree centrality of actor i and x_{ij} represents the elements of the adjacency matrix x. The summation of row values of each and every observation unit (e.g. HHs) has been indicating their degrees. Degree centrality describes many ways in accordance with the notion of ties. Closeness centrality (e.g. Newman, 2010, P. 181) in which measures the mean distance from a vertex to other vertices is measured by suing following formulation;

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[49] Because of, *"social network analysis is a continuously and rapidly evolving field, and is one branch of the broader study of networks and complex systems"* (Hanneman, R.A. and Riddle, M., 2005), Retrieved from: http://faculty.ucr.edu/~hanneman/nettext/index.html (20/10/2017).

$$l_i = \frac{1}{n}\sum_j d_{ij} \qquad (2)$$

Where, l_i signifies the closeness centrality, d_{ij} stands for geodesic distance from actors *i* to *j*. The measure determines how *close* an actor to the rest of other actors in a particular network. Quick interactions are possible with the actors who are located in more central place of network, making shortest paths to others in terms of effective communication sharing (Wasserman and Faust, 1994, P. 183). The closeness centrality with high degree is associated with the positive influence on collective action in disaster response activities (e.g. Bodin & Crona, 2009) and also important for information dissemination in emergency situation (e.g. Misra, *et al*., 2017).

Betweeness centrality indicates the time frequency of an actor lie on the paths between two other actors (Wasserman and Faust, 1994, P.188). The interactions of actors are solely depends on the other actors' geodesic locations. This study considered the betweeness centrality in order to measure the influential actors in higher positions in the flood disaster support networks. Actors with higher betweenness centrality have been made considerable influence on other who located in the same paths (Newman, 2010, P.186). Following formula is used for calculation of betweenness centrality (e.g. Borgatti, Everett, and Johnson, 2013, P. 174);

$$b_j = \sum_{j<k} \frac{g_{ijk}}{g_{ik}} \qquad (3)$$

Where, b_j signifies the betweenness of node *j*, g_{ijk} indicates the amounts of geodesic paths making ties between *i* and *k* via *j*. The total number of geodesic paths which are connecting *i* and *k* indicates by g_{ik}. This value could be zero when a node is not along the shortest path between two other nodes. This can be possible related to the isolated HHs. According to Borgatti, and colleagues (2013, P. 174), betweenness value becomes its maximum, in the situation where a node lies along every shortest path between other pair of nodes. The vertices with high betweenness could be played crucial roles in the network structure.

Quantification of social vulnerability

The epistemology of social vulnerability has been explored through a range of empirical approaches, by examining its causative factors and their causalities as many of them have discussed in the literature review. All the vulnerability applications can be classified into two main categories, for example, quantitative and qualitative approaches. Qualitative studies have been used mostly descriptive ways to investigate the scenarios related with social vulnerability. On the contrary, quantitative applications have been occupied with the quantifying social vulnerability by considering the influences of causative factors. Two groups of scholars are possible to be identified in the light of quantitative approaches for vulnerability studies. One group has been used factor weighting for each and every vulnerability variable based upon expert knowledge and extant literatures (e.g. Abaas and Routray, 2014; Rana and Routray, 2016; Jamshed, *et al.*, 2019 etc.). These applications have used the empirical household survey data and the main drawback behind these applications is that the subjective or arbitrary way of assigning weights for components. The second group has been omitted the application of subjective weightings and occupied with scaling factors considering as equal contributors to the overall vulnerability (e.g. Cutter, *et al.*, 2003; Cutter, *et al.*, 2014; Frazier, *et al.*, 2014; Jha and Gundimeda, 2019 etc.). Those scholars have occupied with national level secondary data and applied for districts or much larger geographical settings. Some of studies have occupied with different way but the equal factor scaling (e.g. also omitting arbitrary way) at national as well as households level (e.g. Human Development Report, 2007; Sullivan, *et al.,* 2002; Hahn, *et al.,* 2009; Adu, *et al.*, 2018). All have some of own strengths and weaknesses as well. I occupied with vulnerability factor scaling by using such balance and different weighting schemes and calculated social vulnerability indexes at household and GND level. I also, considered the IPCC framework (exposure, sensitivity, and adaptive capacity) for vulnerability assessments (e.g. Frazier, *et al.,* 2014; Mainali and Pricope, 2017) in order to compare the reveal results. In accordance with the abovementioned background, I identified five main components and 31 variables (sub-components) which are related to main components for calculating the social vulnerability to flood inundation. Table 3.8 illustrates all the components and their particulars.

Table 3.8: Key components and their variables which considered for social vulnerability quantification

Key component	Variables	Attributes or explanation of variables	Empirical Applications (Sources)
1. Socio-demographic component / 7 variables considered (C1)	i) Number of children (< 5 Yrs) (+)/ s (s = sensitivity)	Children are more vulnerable when flood inundation occurs	Cutter, Bryan, and Shirley (2003); Abbas and Routray (2014); Jamshed, *et al.*, (2019).
	ii) Number of elderly people (> 65 Yrs) (+)/s	Elderly people also are more vulnerable in the flooding events	Cutter, Bryan, and Shirley (2003); Abbas and Routray (2014); Jamshed, *et al.*,(2019).
	iii) Female-headed households (+)/s	Female-headed households are more vulnerable	Hahn, Riederer, and Foster (2009); Adu, et al., (2018).
	iv) Number of female members (+) /s	Females are more vulnerable in the disaster events	Abbas and Routray (2014); Jamshed, *et al.*, (2019).
	v) Households head's education level (-)/ac (adaptive capacity)	When lower the level of education, it leads to higher the vulnerability	Cutter, Bryan, and Shirley (2003); Abbas and Routray (2014).
	vi) Households that reported with no schooling member (+)/s	People who never attend school are more vulnerable for flooding events	Abbas and Routray (2014); Jamshed, *et al.*,(2019).
	vii) Total number of members /family size (+)/ s	Larger families are more vulnerable in the disaster situations	Jamshed, *et al.*,(2019).
2. Physical component / 9 variables considered (C2)	viii) Distance from household to rivers/ tributaries /e (-) (e = exposure)	Households that are located in flood plains are more vulnerable to flood inundation / proximity to rivers	Rana and Routray (2016)
	ix) Inundation depth of households (+)/e	Seriously inundated households are more vulnerable	Rana and Routray (2016)
	x) Duration of flood inundation (+)/e	Lengthier flooding events are more stressful and vulnerable	Rana and Routray (2016)

	xi) Households that have built with clay/hut/tent (+)/s	Unstable households are more vulnerable for flood inundation	Abbas and Routray (2014)
	xii) Household that use firewood as cooking fuel/s	Difficulties and conditions of living incur into more vulnerable livelihoods	Cutter, Bryan, and Shirley (2003); Edger (1999).
	xiii) Households that experienced frequent floods (+) */e*	Households that experiencing frequent floods are more vulnerable	Hahn, Riederer, and Foster (2009); Rana and Routray (2016)
	xiv) Damages experienced by previous floods (+) /e	Previously damaged households are more vulnerable	Rana and Routray (2016)
	xv) Households that located where no tar roads /with gravel (+)/s	Households where located with poor access are more vulnerable for floods	Dewan (2013)
	xvi) Households that don't have alternative access during flooding (+) /s	Households where located with no alternative access during flooding are more vulnerable/they encircle by flood	Hahn, Riederer, and Foster (2009); Dewan (2013)
3. Financial component/ 7 variables considered (C3)	xvii) Households monthly income (-)/ac	Lower income households are more vulnerable for flood inundation	Cutter, Bryan, and Shirley (2003); Mainali and Pricope (2017)
	xviii) Households with unemployed head (+)/s	Households with unemployed heads are more vulnerable	Cutter, Bryan, and Shirley (2003); Jamshed, *et al*.,(2019)
	xix) Number of unemployed members (+)/s	Households with unemployed members are also more vulnerable	Cutter, Bryan, and Shirley (2003); Jamshed, *et al*.,(2019)
	xx) Other economic activities (-)/ ac	Households with no other income sources are more vulnerable	Cutter, Bryan, and Shirley (2003); Jamshed, *et al*.,(2019)
	xxi) Households that didn't receive financial supports (+)/s	Households that didn't receive compensation for damages are more vulnerable	Cutter, Bryan, and Shirley (2003); Adger, 2006.

	xxii) Household with no assets (+)/s	Households with assets like small motor vehicles help them fast moveout	Abbas and Routray (2014)
	xxiii) Dependency ratio* (+)/ s	When higher the ratio, more vulnerable	Hahn, Riederer, and Foster (2009)
4. Health component/ 4 variables considered (C4)	xxiv) Number of members with illness or disabled (+)/s	Households members with illness are more vulnerable	Hahn, Riederer, and Foster (2009); Adu, *et al*., (2018).
	xxv) Average distance to nearest health facility (+)/e	Households located far-away from health facilities, are more vulnerable	Abbas and Routray (2014); Rana and Routray, (2016)
	xxvi) HHs that reported diseases after flood inundation (+)/e	Household members are experienced illness due to floods are more vulnerable	Abbas and Routray (2014) ; Hahn, Riederer, and Foster (2009)
	xxvii) Inundated well (use for drinking water) (+)/e	Households which use inundated and contaminated wells for drinking water are more vulnerable	Abbas and Routray (2014); Rana and Routray, (2016); Adu, *et al*., (2018)
5. Social networks and social capital Component / 4 variables considered (C5)	xxviii) Network degree density of households (average of three phases) (-)/ac	Households with less densities of ties are more vulnerable for disasters	Jones and Faas, (2017).
	xxvix) No of associations' membership of (-)/ac	Households with no collaborations with others in the disaster events are more vulnerable	Cutter, Ash, and Emrich, (2014); Jones and Faas, (2017).
	xxx) Trust about others (-)/ac	Households with no trusting others are more vulnerable	Hahn, Riederer, and Foster (2009); Jones and Faas, (2017).
	xxxi) Average number of friends in their associations reported (-) /ac	Households with no collaborations are more vulnerable in the disaster situations	Jones and Faas, (2017).

Notes: *'+' variables which positively associated with vulnerability; '-' variables which negatively associated with vulnerability;* ** dependency ratio = (< 14 yrs + > 65 yrs)/ (15 -64 yrs population)×100*

Table 3.9: Basic empirical data related to each vulnerability variable

		Rural		Urban	
Key component	Variables	Min	Max	Min	Max
1. Socio-demographic component / 7 variables considered (C1)	i) Number of children (< 5 Yrs)	0	2	0	2
	ii) Number of elderly people (> 65 Yrs) (+)/s	0	3	0	2
	iii) Female-headed households	0	1	0	0
	iv) Number of female members	0	7	0	5
	v) Households head's education level	1*	7**	1	5***
	vi) Households that reported with no schooling member	0	3	0	4
	vii) Total number of members /family size	1	10	1	8
2. Physical component / 9 variables considered (C2)	viii) Distance from household to rivers/ tributaries	5 Meters	5,000 Meters	4 Meters	1,000 Meters
	ix) Inundation depth of households	2 feet	26 feet	1 feet	4 feet
	x) Duration of flood inundation	1 day	14 days	1 day	2 days
	xi) Households that have built with clay/hut/tent	0	1	0	1
	xii) Household that use firewood as cooking fuel	0	1	0	1
	xiii) Households that experienced frequent floods	0	1	0	1
	xiv) Damages experienced by previous floods	0	1	0	1
	xv) Households that located where no tar roads /with gravel	0	1	0	1
	xvi) Households that don't have alternative access during flooding events	0	1	0	1
3. Financial component/ 7 variables considered (C3)	xvii) Households monthly income	4, 000 LKR /22.3 $	63,000 LKR / 352 $	3,500 LKR / 19.6 $	19,000 LKR / 112 $
	xviii) Households with unemployed head	0	1	0	1

	xix) Number of unemployed members	0	6	0	4
	xx) Other economic activities	0	4	0	2
	xxi) Households that didn't receive financial supports	0	1	0	1
	xxii) Household with no assets	0	1	0	1
	xxiii) Dependency ratio*	0	3	0	2
4. Health component/ 4 variables considered (C4)	xxiv) Number of members with illness or disabled	0	4	0	3
	xxv) Average distance to nearest health facility	0.5 km	15 km	1 km	4 km
	xxvi) HH that reported diseases after flood inundation	0	1	0	1
	xxvii) Inundated well (use for drinking water)	0	1	0	1
5. Social networks and social capital Component / 4 variables considered (C5)	xxviii) Network degree density of households ****	0.014	0.2133	0	0.2313
	xxvix) No of associations' membership	0	5	0	2
	xxx) Trust about others*****	0	1	0	1
	xxxi) Average number of friends in their associations reported ******	0	60	0	40

*Notes: * - no schooling; ** - degree / *** - high school; ****- average of three phases; *****-0 =no trust, 1 = trusted; ******- majority of association members they recognized as their friends; rest of all 0 = No and 1 = yes. LKR =Sri Lankan rupees*

The normalization of variables' (sub-components) values is a basic necessity as they have measured at different scales. For examples, age, income, inundation depth, family size etc. Therefore, Min-Max normalization helps to resize/rescale all the variables (values) into analogous or one scale. In contrast, after the normalization, all the variables' values scaled between 0 and 1. Following equations (4 and 5) are used for the normalization of empirical data (UNDP, 2007; Hahn, *et al.,* 2009; Adu, *et al*., 2018; Mainali and Pricope, 2017; Cutter, *et al.*, 2014). Equation (4) occupied with the variables that indicated positive association with vulnerability (indicated with '+ mark' in table 3.8) and equation (5) is applied for the variables that are associated negatively with vulnerability (indicated with '- mark' in table 3.8). Minimum and maximum values of each variable considered separately for urban and rural settings (e.g. table 3.9), as some of extreme values and outliers are identified when considered altogether.

$$index_{s_{ov}} = \frac{s_{ov} - s_{min}}{s_{max} - s_{min}} \quad (4)$$

$$index_{s_{ov}} = \frac{s_{max} - s_{ov}}{s_{max} - s_{min}} \quad (5)$$

Where, s_{ov} is the observed value of variable that related to household *s* and s_{max} and s_{min} are maximum and minimum values of considered variable respectively. After normalized all the sub components, equation (6) is used to calculate the final normalized index/value for each key component.

$$M_{HH} = \frac{\sum_{i=1}^{n} index_{s_{ov}i}}{n} \quad (6)$$

Where, M_{HH} is one of the five key components for considered household (HH). The key components include socio-demographic component (C1), physical component (C2), financial component (C3), health component (C4), social networks and social capital component (C5). $index_{s_{ov}i}$ depicts the variables of key component, indexed by *i* (and *n* represents the number of variables of each component.

Equation (7) is used to calculate Multi Facets Composite Social Vulnerability Index (MFCSVI) for flood inundated households.

$$\text{MFCSVI}_x = \frac{\sum_{i=1}^{n} C_n W_n}{n} \quad (7)$$

Where, MFCSVI is the Multi Facets Composite Social Vulnerability Index for household *x*. C_n represents the numbers of key components and W_n represent the weighting schemes used for the composite index, and *n* ensures the number of key components. After the weighting process, the final cumulative scores of each index (e.g. from W1 to W6) were re-scaled. Table 3.10 illustrates the weighting schemes in which used for the composite index calculation.

Table 3.10: Selected weighting schemes for each key component

Key components / Weighting schemes	Socio-demographic	Physical	Financial	Health	Socio-economic networks and social capital
W1- Balance	0.2	0.2	0.2	0.2	0.2
W2- Socio-demographic based	**0.6**	0.1	0.1	0.1	0.1
W3- Physical based	0.1	**0.6**	0.1	0.1	0.1
W4- Financial based	0.1	0.1	**0.6**	0.1	0.1
W5- Health based	0.1	0.1	0.1	**0.6**	0.1
W6- Networks and social capital based	0.1	0.1	0.1	0.1	**0.6**

According to the table 3.10, weighting scheme 1 (W1) indicates that the balance weighting approach in which considered all key components contribute at similar magnitude to the vulnerability. Second scheme (W2) concerned that the socio-demographic component which make major effect to the households' vulnerability level. Third scheme (W3) implies that the physical component is one of the key factors of vulnerability. Likewise, forth (W4), fifth (W5), and sixth (W6) schemes imply that financial, health, and networks components are predominantly contribute for vulnerability in each index respectively. According to this mechanism, six composite vulnerability indexes (MFCSVI) are calculated for each household. The vulnerability values are ranged from 0 to 1 and 1 represents that the extreme vulnerable and towards zero the vulnerability gradually reduces. The study also used five categories of vulnerability classification for vulnerability mapping, which has discussed in fifth chapter.

Equation 8 is used to weight the IPCC framework based key vulnerability components (e.g. exposure, sensitivity, or adaptive capacity) for each and every household (e.g. Hahn, *et al.*, 2009; Adu, *et al*., 2018).

$$VI_{HHx} = \frac{\sum_{i=1}^{n} K_{HHi} W_{Ki}}{\sum_{i=1}^{n} W_{Ki}} \qquad (8)$$

Where, VI_{HHx} is the vulnerability indicator for household x; K_{HHi} ensures the key components for household and indexed by i; W_{Ki} depicts the weight for each key components (e.g. if such key component has 5 variables and the average value of that component multiplied by 5, and divide by 5 which is the total number of

variables considered for the calculation) and *n* stands for the number of key components considered for vulnerability analysis[50].

In order to compare the results of study MFCSVI approach, IPCC vulnerability framework based the social vulnerability index is calculated by using following equation (9) (e.g. Frazier, *et al.*, 2014; Mainali and Pricope, 2017).

$$ESAC = (E + S) - AC \quad (9)$$

Where, *ESAC* defines the overall social vulnerability, *E* stands for the exposure, *S* represents the sensitivity, and *AC* ensures the adaptive capacity of households. All the variables (n=31) considered for the quantification of social vulnerability to flood inundation have indicated with the respective key themes (e.g. exposure, sensitivity, and adaptive capacity) in the table 3.8 for the calculation of equation 8.

Abovementioned variables (factors) and their major components have identified by many vulnerability applications (according to the extant literatures) as influencing causative factors the ways in which adversely affecting to the social vulnerability and people's livelihood. According to the table 3.8, five main components and 31 related variables are identified/recognized from the empirical data in which collected from 405 households. Table 3.9 shows minimum and maximum values (e.g. rural/urban) of all variables. Component one (C1) represents the socio-demographic factors including 7 variables. Mainly, children (< 5 yrs) and elderly people (> 65 yrs) are recognized as more vulnerable for flooding events. Especially, during flood inundation, supporters and family members have been faced a range of impediments evacuating with elderly and children. Similarly, female members of household and female-headed households are identified as more vulnerable in the flood disaster event. This is because they are inherently very sensitive to all the kinds of disasters and are being faced difficulties in plenty. Particularly more than half of female members even in rural areas do not have much experiences for swimming. Family members who never attend to schools are also considered as more vulnerable because making sudden decisions and managing them in adverse situations are quite difficult. More importantly, family size also has been influenced for evacuation activities during flood inundation. For example, some of rural inundated households are identified with around 10 family members.

Second component consists of the physical factors in which influenced for flood inundation vulnerability. Rivers and their tributaries have often been the main

[50] For detail explanations, please see, Hahn and Colleagues (2009).

causations for frequent flooding in both rural and urban areas. Therefore households are situated more close juxtapositions to rivers are more vulnerable obviously. And also, the relationship is negative with vulnerability as the HHs where located faraway have been experiencing low depth flood inundation somehow it depends also on the altitude of location. Therefore, inundation depth is also a predominant physical factor of vulnerability. This is because some of HHs in which situated in low-lying areas of Elapatha DSD have been experiencing more than 20 feet inundation depth and some of them are disappeared with mass flooding events. Similarly, there has been a strong association between inundation depth and flood duration. Some of HHs have experienced more than two weeks flood inundation located in Elapatha DSD and they are being more vulnerable. The HHs have built of clay, wooden boards or other temporary materials are also more vulnerable (e.g. their physical condition). Many of HHs situated in urban informal settlements have built with very light-wooden materials. Some HHs are built with clay in rural inundated areas also are more vulnerable. More importantly, HHs that are experiencing frequent floods (e.g. yearly or two or three times per year) and damages by previous floods are also considered as more vulnerable. And also, some of HHs (especially rural) are located in very remote areas and they don't have proper accesses (e.g. tar roads). These HHs have facing difficulties and vulnerable when flood inundation occurs. Many of rural villages have been encircled by rushing floodwaters and isolated from other areas (e.g. many of villages in both Elapatha and Kuruwita DSDs). This is because the external supplies and access have been blocked during flood inundation and they are considered as more vulnerable. In addition, HHs who have been used firewood as cooking fuels are also more vulnerable in particular during and after the disaster like flood inundation. Their livelihood adversely affects by these circumstances.

Third component is the financial background and related factors of HHs. The majority of rural as well as urban-informal households are not financially viable. In other words, poorer households are more vulnerable for flood disasters. Therefore, monthly income of households indicated with negative association with social vulnerability. In contrast, with the increasing of HHs income levels, their vulnerability is being reduced. Their monthly incomes range from 3,500 SL Rupees (= 19.6 $) to 19,000 SL Rupees (= 112 $) and from 4,000 SL Rupees (= 22.3 $) to 63,000 SL Rupees (= 352 $) in urban and rural areas respectively. More importantly, table 3.4 also depicts the average figures of selected variables. HHs are reported with unemployed heads and also with the numbers of unemployed members are considered as more vulnerable to flood inundation. Other economic activities (e.g. agriculture, self-employment etc.) of HHs members are helped to reduce the vulnerability and exemplified a negative association with vulnerability.

HHs that didn't receive financial supports after flood inundation also are considered as vulnerable HHs. Many of HHs are reported with no assets (e.g. motor bike, three wheeler etc.) and they are also recognized as vulnerable HHs. With larger the dependency ratio, vulnerability also goes up.

Health facility and illness related factors considered as heath component for the vulnerability quantification. In particular, HH members with disability or illness and HHs that reported diseases after flood inundation considered as vulnerable HHs. And also, average distance from HHs to health facilities are also recognized as vulnerability factor. This is because, some of rural HHs are located very far away from health facilities and they are more vulnerable for disasters. The majority of HHs in rural areas has been using wells as drinking sources. Therefore, after inundation of their wells inundated and contaminated. This is because HHs are experiencing difficulties with drinking water and they are more vulnerable.

Finally, socio-economic network and social capital component is considered. Firstly, I concerned socio-economic network degree density as one of the influential factors / variables by the ways in which helped to ameliorate social vulnerability to flood inundation. I calculated the average density values (from before, during, and after phases) for each HH and have a negative association with vulnerability. And also, number of membership associations, trust on others, and associational friends are considered as social capital variables. The application of socio-economic network densities to the composite index can be considered as one of major contributions of this research similarly with social capital variables. For the measuring of social capital, the study used Integrated Questionnaire for the Measurement of Social Capital (SC-IQ), which is introduced by the World Bank (Grootaert, *et al.,* 2004). In particular, the most relevant sub categories of SC-IQ framework only considered for this study.

Data analysis

According to the mix method approach, both quantitative and qualitative data analysis techniques are applied for empirical data analysis of this study. As I explained earlier in this chapter, all the household data (327 and 78, rural and urban informal households respectively) imported into the IBM SPSS statistics – 23rd version and individual information of household members are entered into MS Excel-2010 and occupied with analysis basically by using filtering and pivoting options. Similarly, network data and relevant databases also are managed using MS Excel-2010 and finally imported into the UCINET version 6.679 program (Borgatti *et al*., 2002).

Regarding the network data analysis, all the network matrixes (all were one-

mode matrixes) were created in MS Excel program. Households numbers (from 1 to 405) and relevant supporters' identification numbers entered in columns and rows similarly and asymmetric network matrixes were used. This is because in the before and during flood inundation phases, none of outgoing supports (e.g. from households) were identified. Some of incoming and outgoing links among households were identified at the after phase. Finally, all the matrixes were imported into the UCINET program and Social Networks Analysis (SNA) techniques were occupied for analyzing network measures such as degree density, betweenness and closeness centralities etc. and for network graph analysis. In particular, NetDraw version 2.168 (Network Visualization Software is attached to the UCINET) was used for the network graph mapping, visualization and related analysis.

In order to develop composite social vulnerability indices, all the socio-economic data and networks measures were analyzed using SPSS and Excel programs. And also those software were used for making cross-tabulations and for data manipulation purposes related to socio-economic networks and social capital information. Moreover, SPSS program was occupied for the statistical analysis such as pared sample t-tests, cross tabulations, and other basic analysis etc. ArcMap GIS 10.3.1 program (ESRI, 2015) was used for all the mapping and spatial analysis purposes. Households' locations also collected by household survey are used to household level vulnerability mapping.

Regarding the qualitative data analysis, the data by the ways in which collected through focus group interviews and some of informal interviews were considered. Majority of these data were transcribed and tape-recoded in accordance with interviewees' consent. In particular, respondents' narratives and responses (feelings) are used to determine the prowess of their networks in ameliorating vulnerability. For this, study occupied with some of thematic and narrative analysis in accordance with the data and information necessities. In particular, finally for data visualization, tabulations, graphs and charts, network graphs and maps were used. This chapter discussed all the empirical applications and methodologies in details used for the study.

Chapter 4. Spatio-temporal dynamics of socio-economic networks for flood disaster preparedness and recovery

This chapter reveals undeniable evidences on village socio-economic networks in the flood inundation events and also offers preeminent yardsticks of socio-economic network discourse in the flooding events. The legacy of socio-economic networks has been identified as one of the significant and leading instrumental exponents in terms of responding, recovering, and reviving flood affected livelihoods in the Sri Lankan context. None of empirical studies can be found in the context of examining the role and the behaviors of these reciprocal ties and their influence on responding and recovering flood inundation events and their consequences related to Sri Lanka. The household survey proved that the pivotal role in which played by socio-economic networks and social capital in securing and revivifying the village level flood-effected livelihoods. This study demonstrates those narratives through selected network measures in which explained in the chapter three. In accordance with this contextual background, next sections provide detail information of the revealed results related to all the 21 local admin units (GNDs) which are belonging to rural and urban sectors.

4.1. Spatio-temporal evolutionary dynamics of reciprocal supports, network measures, and network graphs

Socio-economic networks[51] provide required impetus for resilience activities in all the means throughout villages. Respondents explained that the nature of resilience activities when the flooding events are unfolded. In accordance with surveyed data, a range of reciprocal supports is categorized. For examples, information provision; evacuation and moving out belongings; provision of food, water, and other basic needs including health supports, provision of shelters; emotional supports; move in back belongings of HHs; cleaning contaminated (e.g. mudded) HHs and public places and financial supports. Majority of respondents have received abovementioned supports as a whole/the combination of supports. For example, information provision, moving out belongings and evacuation could be done by the same person (s). Therefore, it is difficult to detach one from another in practical sense. The types of supports received are presented as percentages

[51] A part of this chapter (e.g. the spatio-temporal evolutionary dynamic of socio-economic networks …) is under review as a research paper of an international journal.

belonging to before, during, and after flood inundation phases. It is obvious that the explaining of findings and particulars at individual households (HHs) level is cumbersome and make complex in all the means. This is because, the information are very broad pertaining to 405 HHs. Therefore, results explained by GNDs, DSD, and sector levels. Nevertheless, the highlights and special particulars are explained in HHs level in accordance with the necessities.

4.1.1. Kuruwita DSD – reciprocal supports and socio-economic networks

All the surveyed HHs of Kuruwita DSD are belonged to the rural sector. Therefore they exemplified much interlaced collaborations particularly at after flood inundation phase compared to the before and during phases. Figure 4.1 illustrates the different categories of supports received by HHs in related to the three phases (Kuruwita sample, n = 114 HHs). Particularly in the before phase, 'information provision', and 'evacuation and moving out belongings' are identified as the predominant reciprocal supports in almost all the GNDs (e.g. overall 76.77%; with Min 68.23%, Kitulpe, and Max 84.92%, Pahalagama; see, Appendix 1, Table A-1). The rest of support for example, provision of food, water and other basic needs including health supports; provision of shelters and emotional supports (e.g. 8.93%, 14.30% respectively) are recoded with low magnitudes. Especially, a majority of HHs are tried to evacuate and moving out their belongings before inundate their HHs. Particularly, at during flood inundation, the most influential supports are provision of foods, basics needs, emotional supports and shelters (e.g. average 79.55%; with Min 75.5%, Kitulpe and Max 82.39%, Pahalagama). Many of them have stayed at their relatives and friends places and others in community centers such as temples and public schools during flood inundation. There is no balance of supports between before and during phases, as some of HHs members of the same household have evacuated at before as well as during phases in accordance with the availability of the boats.

Some of them have evacuated during the flood inundation (e.g. 20.45%; with Min 18.5%, Miyanadeniya and Max 24.5%, Kitulpe) as they have stayed their houses until the floodwaters are surrounded their dwelling units. They mentioned that sometimes the inundation level is started to reduce with the termination of torrential rains. Their guestimates are challenged when the upper catchment areas are experienced heavy torrential rains rather than down valley areas. By contrast, the inundation levels of down valley areas are solely depending on the intensity of the rainfall received by the upper catchment areas. Kuruwita DSD experienced flooding events due to Kuru River and it has comparatively large upper catchment

areas. In the after phase, move in back belongings of HHs; cleaning contaminated (e.g. mudded) HHs and public places are identified as the dominant supports categories are being received by the HHs (e.g. 94.14%; with Min 90.54%, Theppanawa and Max 97.5%, Kitulpe). In particular, many ties are emerged after flooding events. Financial supports are also can be seen in the after phase (e.g. 5.86%; with Min 2.5% kitulpe, and Max 9.46%, Theppanawa) and usually not immediately after the flooding events (e.g. government aids). Miner differences are seen among the GNDs and but not major variations observed.

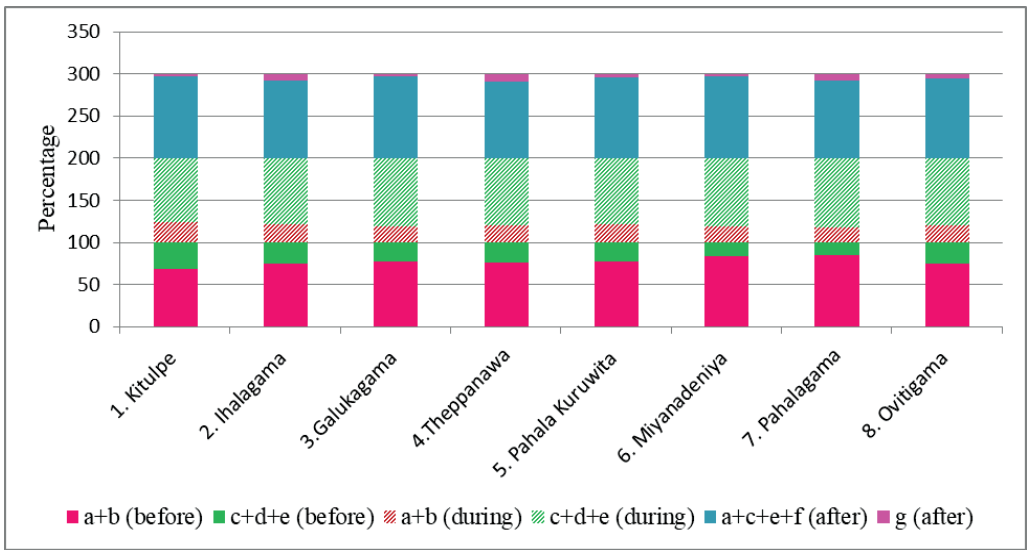

Figure 4.1: Reciprocal supports that HHs received at before, during, and after flood inundation, Related to Kuruwita DSD (for data; see, Appendix 1, Table A-1).
Notes: a- information provision; b- evacuation and moving out belongings; c-food, water and other basic needs including health supports; d- provision of shelters; e- emotional supports; f- move in back belongings of HHs, cleaning contaminated (e.g. mudded) HHs and public places; g- financial supports.

Source: Own household survey, 2018/2019.

Table 4.1 depicts the involvement of actors before, during, and after the flooding events. Helpers are categorized into three main categories namely, admin officials or volunteers, relatives, neighbors and friends. At the before phase, neighbors and friends have supported HHs mainly (e.g. 54.74% on average; with Min 35.29%, Ovitigama and Max 70.37% Galukagama) and then by the relatives (34.6%; with Min 25%, Ihalagama as well as Pahala Kuruwita and Max 52.94%, Ovitigma). Among GNDs, quite considerable variations can be seen. Generally regarding the admin officials, each GND has one GNO and sometimes one GNO has assigned for two or three GNDs for general admin works.

Table 4.1: Changing patterns of involved network actors over time (before, during, and after) (%), related to Kuruwita DSD.

GNDs	Before			During			After		
	A	B	C	A	B	C	A	B	C
1. Kitulpe	10.00	30.00	60.00	6.25	75.00	18.75	9.38	37.50	53.12
2. Ihalagama	8.33	25.00	66.67	5.56	55.56	38.89	12.50	40.63	46.88
3.Galukagama	3.70	25.93	70.37	8.70	73.91	17.39	11.29	32.26	56.45
4.Theppanawa	15.38	34.62	50.00	9.09	63.64	27.27	14.29	64.29	21.43
5.Pahala Kuruwita	12.50	25.00	62.50	18.18	63.64	18.18	12.00	52.00	36.00
6.Miyanadeniya	12.50	50.00	37.50	11.76	70.59	17.65	11.11	55.56	33.33
7.Pahalagama	11.11	33.33	55.56	20.00	50.00	30.00	13.79	27.59	58.62
8. Ovitigama	11.76	52.94	35.29	8.33	75.00	16.67	3.45	55.17	41.38
Average	10.66	34.60	54.74	10.98	65.92	23.10	10.98	45.62	43.40

Notes: A - Admin officials and volunteers; B – Relatives; C - Neighbors and friends.

Source: Own HHs surveyed, 2018/2019

Particularly regarding some GNDs, for instance, Ovitigama, the GNO has played major roles in managing and facilitating HHs and none of volunteers are seen in during phase related to sample HHs. Also, percentage figures indicate the proportional figures by comparing all the actors of HHs. In during phase relatives have made dominant supports (65.92%; with Min 50%, Pahalagama and Max 75%, Kitulpe as well as Ovitigama) while others are occupied with 34.08 per cent on average. Relatives, neighbors, and friends are helped mainly (89.02%) in after phase relatively while secondly by admin and volunteers (e.g.10.98%, with Min 3.45%, Ovitigama and Max 14.29%, Theppanawa) Nevertheless, after flooding events, many volunteers are seen providing with a range of reciprocal supports. Meanwhile, Ovitigama (phase), Miyanadeniya (phase 1 and 3), Theppanawa (phase1), and Pahala Kuruwita (Phase3) exemplified some of different patterns on supports (e.g., table 4.1).

Network degree density determines by the existing actual ties and possible ties (proportionate) of a network. Regarding the network degree density, resultant figures which are related to all three phases and regions are quite low (table 4.3). In the fully saturated networks (e.g. ‘complete’ graphs), the network density is equal to one and this kind of situation is very rare even in the very small networks (e.g.

Scott, 2010, P.69-70). This may because some of networks with small number of actors (e.g. nodes) are also depicted comparatively higher density values, as their networks sizes (e.g. mainly number of actors) are small. In contract, they have fewer numbers of actors and ties compared to some other larger networks. On the other hand, in particular in the flooding events, with the increasing number of actors, the numbers of ties are not increasing simultaneously. In other words, a range of actors can be found with no ties with other rest of actors of their support networks. This is because their network densities are quite low compare to small networks.

Table 4.2 illustrates that the spatial and dynamic nature of the socio-economic network measures related to before, during, and after flood inundation phases in sampled GNDs of Kuruwita DSD. The revealed results indicate that the key measures for examples, degree density, closeness, and betweenness centralities have decreased from before phase to during phase and then increased in the after phase compare to during and before phases in almost all the GNDs (e.g. regarding average figures; degree density: 0.04, 0.03, 0.05; closeness centrality: 21.74%, 18.39%, 22.73%; betweenness centrality: 5.34%, 4.00%, 9.11% respectively). More importantly, GND level differences are observed regarding the abovementioned key measures. For instances at before phase, the minimum values of density, closeness, and betweenness measures are indicated from Galukagama (0.02, 17.3%), and Ihalagama (2.2%) while maximum figures depict from Pahala Kuruwita (0.053, 25.7%, and 8.7%) respectively (table 4.2). Regarding during phase, minimum values of density, closeness, and betweenness measures are illustrated from Galukagama (0.018, 16.2%) and Ihalagama (1.8%) while maximum values indicate from Pahalagama (0.046), Pahala Kuruwita (22.4%, 6.8%) respectively. In after phase, the key measures are exemplified with upsurges. For instances, the lowest values of density, closeness, and betweenness measures are highlighted from Galukagama (e.g. 0.025, 21.7%, and 4.1%) while the highest figures are showed from Pahala Kuruwita (e.g. 0.056, 40.1%, and 14.5 %) respectively. All of these figures are solely based on the nature of actors' reciprocal ties among different phases and will discuss in the comparison section in details.

Similarly, figures of average degree have decreased from before phase (e.g. average 0.99, with Min 0.810, Kitulpe and Max 1.219, Theppanawa) to during phase (e.g. average 0.89, with Min 0.7, Theppanawa and Max 1.042, Pahala Kuruwita). The average degree scores then have increased at after phase (e.g. average 1.96, with Min 1.455, Theppanawa and Max 2.32, Ihalagama). On the contrary, the degree centrality has increased from before phase (e.g. on average, 26.99%) to during phase (e.g. 27.16%) and then has decreased at after phase (e.g. 22.73).

Table 4.2 : Spatial and dynamic nature of the Network measures related to before, during, and after flood inundation, Kuruwita DSD

GNDs	Before flood inundation					During flood inundation					After flood inundation				
	D	Ad	Dc (%)	Cc (%)	Bc (%)	D	Ad	Dc (%)	Cc (%)	Bc (%)	D	Ad	Dc (%)	Cc (%)	Bc (%)
1. Kitulpe	0.040	0.810	23.2	22.3	6.5	0.034	0.889	29.5	21.8	4.7	0.044	1.909	35.8	39.0	8.6
2. Ihalagama	0.033	0.931	34.8	21.8	2.2	0.025	0.889	33.6	20.5	1.8	0.047	2.320	16.3	39.2	9.2
3. Galukagama	0.02	1.073	19.1	17.3	3.4	0.018	0.922	25.1	16.2	2.2	0.025	2.293	18.8	21.7	4.1
4. Theppanawa	0.039	1.219	19.9	22.9	5.3	0.037	0.700	19.3	17.1	4.6	0.045	1.455	18.4	25.3	8.6
5. Pahala Kuruwita	0.053	0.947	37.6	25.7	8.7	0.045	1.042	33.0	22.4	6.7	0.056	2.079	19.7	40.1	14.5
6. Miyanadeniya	0.043	1.077	38.7	21.8	5.6	0.03	1.029	28.0	15.2	3.2	0.052	1.806	24.8	38.6	12.4
7. Pahalagama	0.048	0.765	22.9	22.7	5.9	0.046	0.778	20.3	16.3	4.5	0.049	1.757	24.2	23.4	9.8
8. Ovitigama	0.034	1.091	19.7	19.4	5.1	0.032	0.857	28.5	17.6	4.3	0.043	2.061	23.8	29.3	5.7
Average	0.04	0.99	26.99	21.74	5.34	0.03	0.89	27.16	18.39	4.00	0.05	1.96	22.73	32.08	9.11

Notes: D= Degree density; Ad = Average degree; Dc= Degree Centrality; Cc = Closeness Centrality; Bc = Betweenness Centrality; All the Dc and Bc values are normalized.

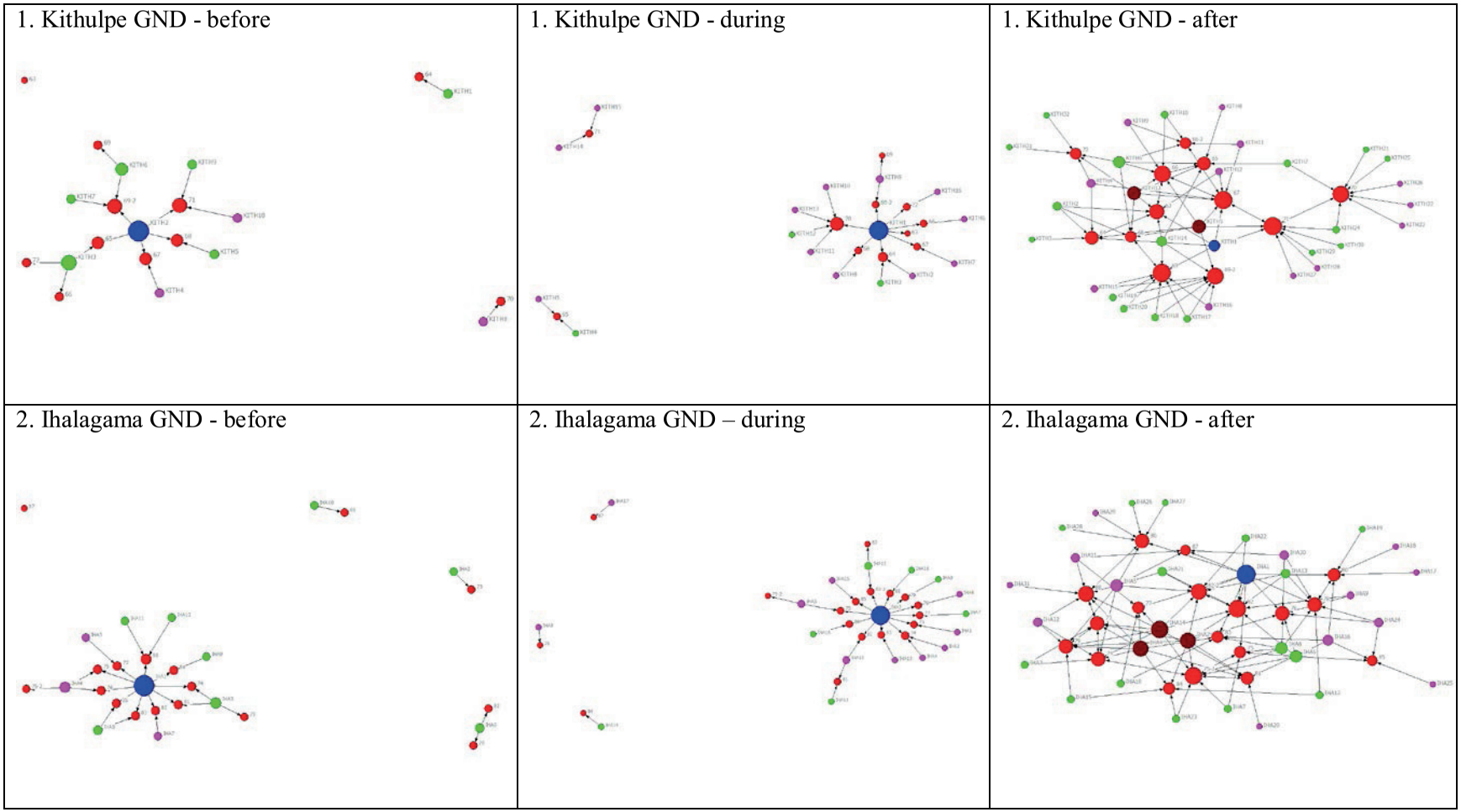

Figure 4.2: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Kithulpe and Ihalagama GNDs. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

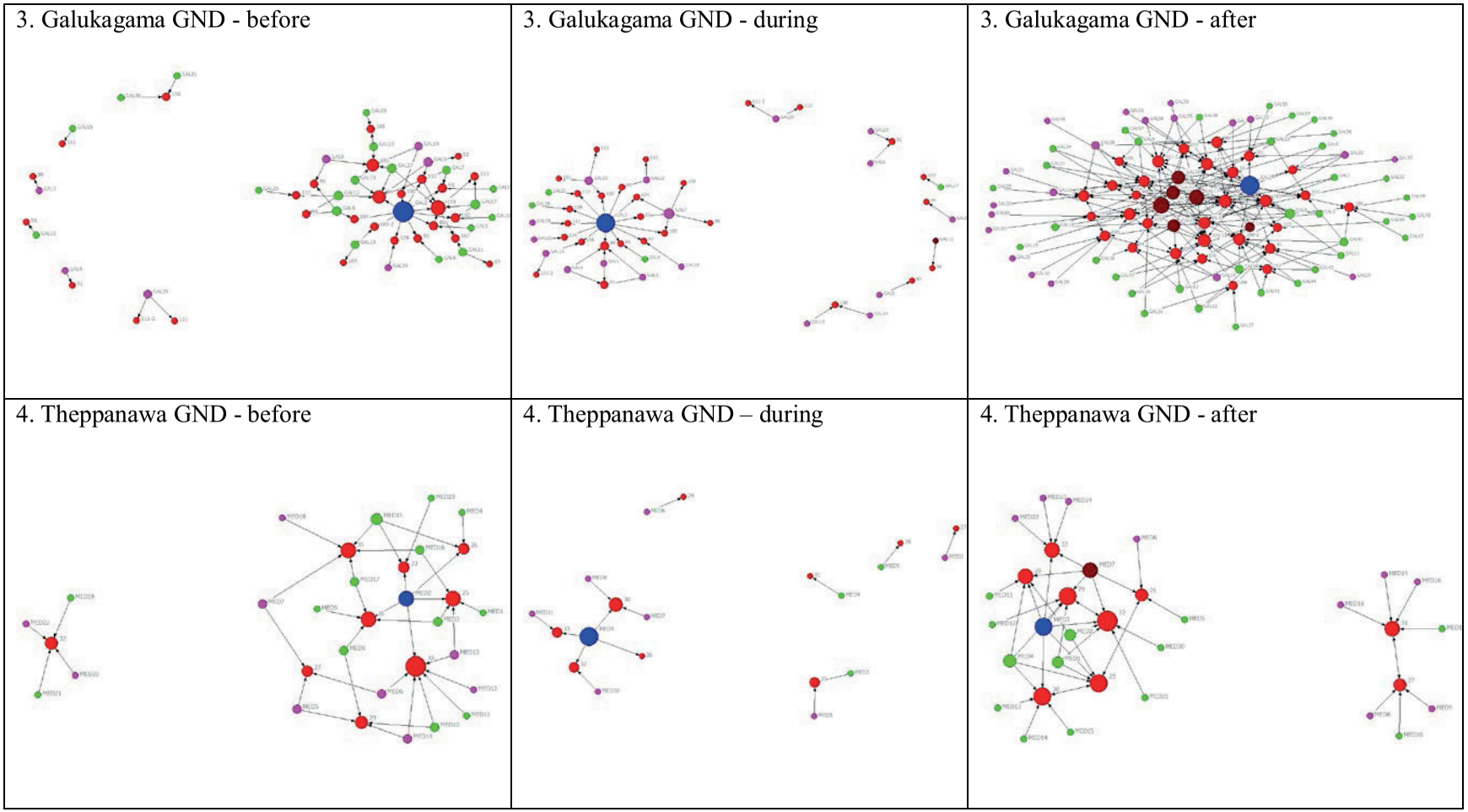

Figure 4.3: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Galukagama and Theppanawa GNDs. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

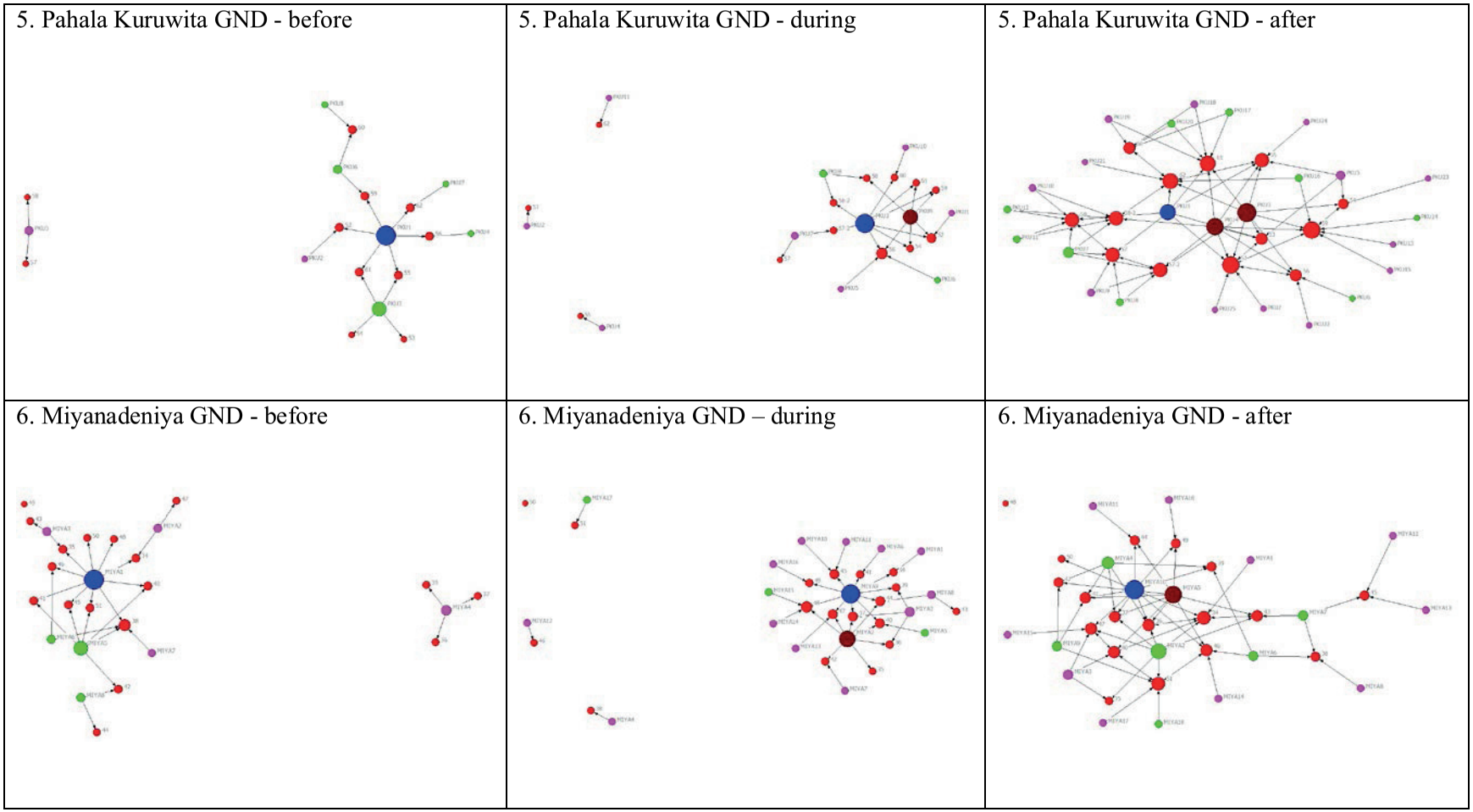

Figure 4.4: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Pahala Kuruwita and Miyanadeniya GNDs. *Notes*: *The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

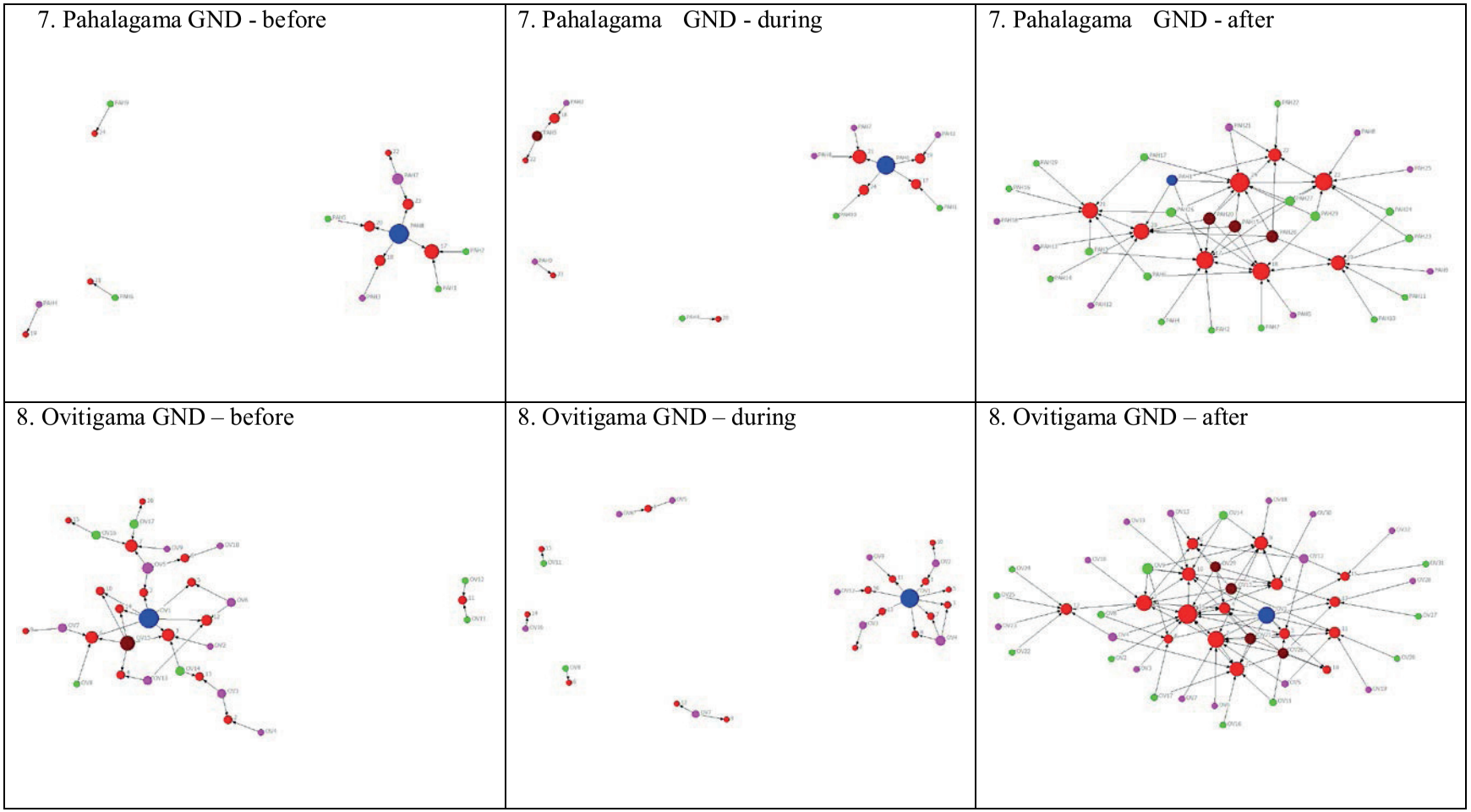

Figure 4.5: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Pahalagama and Ovitigama GNDs. *Notes*: *The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

Figures 4.2 – 4.5 show that the dynamic and spatial patterns of socio-economic networks and their evolutionary patterns over time in all the sampled GNDs related to Kuruwita DSD. More importantly, according to 4.2-4.5 figures, all the GNDs are exemplified with quite clustered nature with many sub-groups at before and during phases compare to the after phase (e.g. Ihalagama, Galukagama, Pahalagama, Kitulpe). Regarding the before phase, in particular, HHs have been received helps mainly from neighbors and friends, and then from relatives. In practically, helpers (e.g. neighbors, friends, and relatives) do not have much opportunity to provide helps for all the inundating HHs and they first engage with known HHs. Of each HHs are represented with some pare of ties (except few HHs). This nature represents as sub-groups (clusters) in network graphs (Fig. 4.2-4.5). Some sub-groups have quite larger ties compare to the rest of others subgroups because of they may have known each other rather than small subgroups. And also in during phase, all the GNDs are exemplified clustered ties or subgroups (e.g. mainly Galukagama, Theppanawa, Ovitigama etc.). This is because many of HHs members have stayed at their relatives' or friends' places during flooding. Others have stayed evacuation centers (e.g. community centers) and they have engaged with many supporters making dense ties compare to others (e.g. larger subgroups). Theppanawa and Ovtigama GNDs indicate more subgroups at during phase compare to before phase.

More importantly, after phase has indicated with quite distributed ties compare to the rest of phases. Almost all the GNDs are exemplified with distributed ties at after phase except Theppanawa GND. Regarding Theppanawa GND, two HHs have received helps from two groups of supporters and they have not engaged with the rest of HHs. And also, that two HHs have helped each other in terms of cleaning and rearranging their HHs and belongings. In particular, at the after phase, floodwaters have almost been drained and access pathways are reopened. Therefore, many reciprocal supports have been mobilized and supports have engaged with many HHs compare to the rest of phases. Some of supporters are from outsides of villages and are volunteers. For examples, many volunteers are seen at the after phase compare to other phases (e.g. Ovitigama, Galukagama, Ihalagama). This is because more knitted collaborations and ties are observed at after phase. Despite, some isolated HHs also are identified rarely (e.g. Kitulpe and Ihalagama at before phase; Miyanadeniya at all the phases). Respondents of those HHs are pointed that no one helped them in the flood inundation events. On the contrary, GNOs are pointed out that they helped all the affected HHs in all the means. In particular, some of isolated HHs are possible to be identified even in the more interlaced rural societal settings. Interestingly, some of HHs also are showed with quite large

symbols (in Red color) especially at after phase due to their denser ties (because of the size of the symbols are proportionate to their degree density).

4.1.2. Elapatha DSD – reciprocal supports and socio-economic networks

The entire sample GNDs (n = 7) of Elapatha DSD are belonged to the rural sector and investigated with rich social collaboration and reciprocal supports in the flooding events in accordance with the survey data (Elapatha sample, n = 213 HHs).

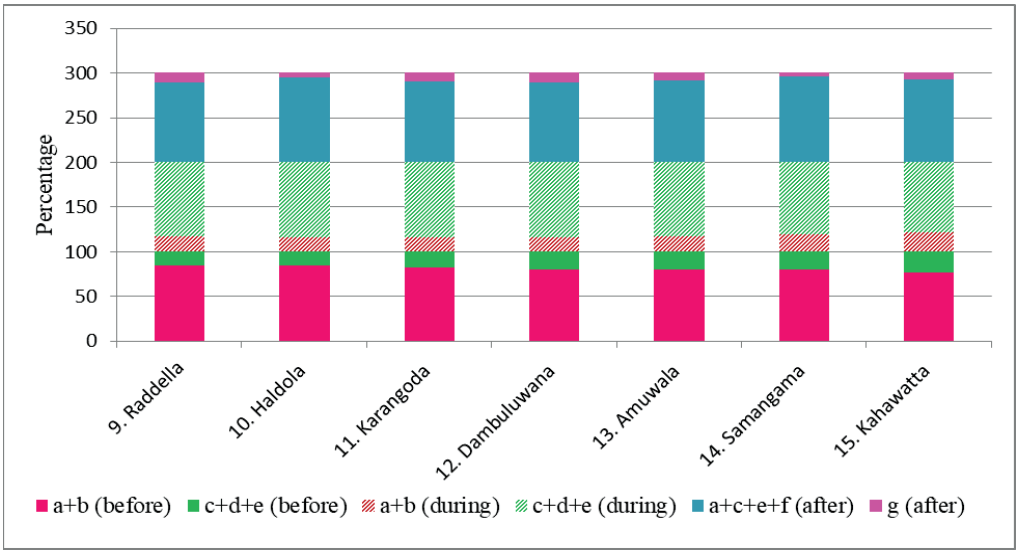

Figure 4.6: Reciprocal supports that HHs received at before, during, and after flood inundation (%), Related to Elapatha DSD (for data; see, Appendix 1, Table A-1).
Notes: a- information provision; b- evacuation and moving out belongings; c-food, water and other basic needs including health supports; d- provision of shelters; e-emotional supports; f- move in back belongings of HHs, cleaning contaminated (e.g. mudded) HHs and public places; g- financial supports.

Source: Own HHs survey, 2018/2019.

Figure 4.6 presents a range of reciprocal supports received by each GND (e.g. averages of respective HHs) in related with before, during, and after flood inundation events. According to the revealed results, categories of information provision and evacuation and moving out belongings are identified as the main reciprocal supports received by HHs before phase (e.g. average 81.12%; with Min 76.75%, Kahawatta and Max 84.94%, Haldola; see, Appendix, Table A-1). Provision of shelters is indicated as the second crucial category of helps in this

phase (e.g. 15.51%; with Min 13.6% Haldola and Max 20.65%, Kahawatta). Provision of foods and emotional supports are not important in before phase (e.g. 3.37%; with Min 1% Raddella and Max 6.79% Amuwala). This is because, a majority of HHs are hurrying and readying for moving out before flood inundation and they contacted with others particularly during and after flooding. Regarding the during phase, provision of foods, water and other basic needs; sheltering, and emotional helps are highlighted as the predominant supports chains (e.g. 82.3%; with Min 78.68%, Kahawatta and Max 84.11%, Haldola). Information and evacuation supports (e.g. 17.07%) are revealed as the second category of during phase. In the after phase, importantly, provisions of foods, basic needs, emotional helps, moving in belongings are recoded as crucial supports (e.g. 92.07%; with Min 89.39%, Raddella ; Max 96.55, Samangama) and then the financial supports with lesser amount (e.g. 7.93%; with Min 3.45%, Samangama and Max 10.61%, Raddella).

Table 4.3: Changing patterns of involved network actors over time (before, during, and after) (%), Related to Elapatha DSD.

GNDs	Before			During			After		
	A	B	C	A	B	C	A	B	C
9. Raddella	3.13	31.25	65.62	11.49	52.87	35.64	10.77	26.15	63.08
10. Haldola	2.86	28.57	68.57	7.55	58.49	33.96	7.22	36.08	56.70
11. Karangoda	2.70	35.14	62.16	23.08	61.54	15.38	5.81	41.86	52.33
12. Dambuluwana	4.76	33.33	61.90	25.00	60.00	15.00	11.43	31.43	57.14
13. Amuwala	2.44	17.07	80.49	15.63	50.00	34.38	2.90	28.99	68.12
14. Samangama	4.76	47.62	47.62	7.69	50.00	42.31	6.12	42.86	51.02
15. Kahawatta	6.25	31.25	62.50	10.00	70.00	20.00	8.00	20.00	72.00
Average	3.84	32.03	64.13	14.35	57.56	28.09	7.46	32.48	60.06

Notes: A - Admin officials and volunteers; B – Relatives; C - Neighbors and friends.
Source: Own HHs surveyed, 2018/2019

Table 4.3 illustrates the socio-economic network actors' involvements over different phases of flood inundation with flood affected HHs in Elapatha DSD. Regarding the admin officials and volunteers, results indicated much collaboration in during phase (e.g. 14.35%; with Min 7.55%, Haldola and Max 25%, Dambuluwana) compare to before (e.g. 3.84%; with Min 2.44%, Amuwala and

Max 6.25%, Kahawatta) and after (e.g. 7.46%, with Min 2.9%, Amuwala and Max 11.43% Dambuluwana) phases. Relatives also engaged with higher per cent in during phase (e.g. 57.56%; with Min 50%, Amuwala as well as Samangama and Max 70%, Kahawatta) rather than before (e.g. 32.03%; with Min 17.07%, Amuwala and Max 35.14%, Karangoda) and after (e.g. 32.48%; with Min 20%, Kahawatta and Max 42.86%, Samangama) phases. In particular, Neighbors and friends are crucial in both before (e.g. 64.12%; with Min 47.62%, Samangama and Max 80.49 %, Amuwala) and after (e.g. 60.06%; with Min 51.02% and Max 72%, Kahawatta) phases rather than during phase (e.g. 28.09%; with Min 15%, Dambuluwana and Max 42.31%, Samangama). All in all, a range of collaborative reciprocal supports can be seen, in accordance with revealed results pertaining to Elapatha sampled HHs.

Similar narratives and socio-economic network behaviors are exemplified in related to Elapatha sampled GNDs as all of them are belonged to the rural geographical settings. Table 4.4 illustrates that the spatial and temporal evolutionary patterns of network measures related to before, during, and after flood inundated phases. Regarding the key network measures (e.g. degree density, closeness, and betweenness centralities), they have decreased from before phase to during phase and then have increased at after phase in all the sampled GNDs. It is cardinal important to examine the regional diversities of these measures as they exemplify the socio-economic network behaviors of regional settings at flood inundation events. According to the table 4.4, the degree density at before phase is ranged from 0.011 (Min, Haldola) to 0.037 (Max, Kahawatta) with the average of 0.02 and then has decreased at the before phase (e.g. Min. 0.01, Haldola and Karangoda; Max. 0.035, Kahawatta; average, 0.02), finally has increased at the after phase (e.g. Min. 0.012, Haldola; Max. 0.041, Kahawatta; average 0.02). Despite, the average degree density has been the same (e.g. 0.02) at all the three phases. This may mainly because the variations of density figures among GNDs are quite high and higher values are influenced by the small values. The closeness centrality is ranged from 13.2% (Min, Amuwala) to 21.2% (Max, Dambuluwana) with the average of 16.5% at the before phase and then at during phase has decreased (e.g. Min. 10.2%, Raddella ; Max. 18.9%, Kahawatta with the average of 14.13%), while at after phase has increased (e.g. Min. 15.1%, Haldola; Max. 27.6%, Kahawatta, with the average of 19.0%). Similar narratives are observed regarding the betweenness centralities among Elapatha GNDs. For instances, at the before phase, figures are varied from 1.3% (Min, Haldola) to 4.9% (Max, Kahawatta) with the average of 2.71%.

Table 4.4: Spatial and dynamic nature of the Network measures related to before, during, and after flood inundation, Elapatha DSD

GNDs	Before flood inundation					During flood inundation					After flood inundation				
	D	Ad	Dc (%)	Cc (%)	Bc (%)	D	Ad	Dc (%)	Cc (%)	Bc (%)	D	Ad	Dc (%)	Cc (%)	Bc (%)
9. Raddella	0.012	0.896	19.1	14.9	1.4	0.009	1.156	15.8	10.2	1.2	0.017	1.829	23.3	17.9	2.9
10. Haldola	0.011	0.870	28.5	14.2	1.3	0.010	0.990	20.2	13.2	1.1	0.012	1.609	9.9	15.1	2.3
11.Karangoda	0.013	0.947	23.7	16.9	1.8	0.010	1.275	10.7	12.8	1.0	0.016	1.269	29.0	17.2	2.5
12. Dambuluwana	0.022	1.042	26.5	21.2	3.3	0.021	0.957	20.5	17.4	2.8	0.024	1.523	10.4	20.4	3.8
13.Amuwala	0.014	1.066	12.2	13.2	3.1	0.013	0.881	12.7	12.6	1.7	0.015	1.649	10.5	15.6	2.4
14. Samangama	0.018	0.773	10.3	15.4	3.2	0.017	0.721	8.2	13.8	2.1	0.020	1.362	13.1	19.2	3.2
15. Kahawatta	0.037	0.880	18.7	20.0	4.9	0.035	0.632	14.7	18.9	4.4	0.041	1.40	20.6	27.6	5.4
Average	0.02	0.92	19.86	16.54	2.71	0.02	0.94	14.69	14.13	2.04	0.02	1.52	16.69	19.00	3.21

Notes: D= Degree density; Ad = Average degree; Dc= Degree Centrality; Cc = Closeness Centrality; Bc = Betweenness Centrality; All the Dc and Bc values are normalized.

At during phase, betweenness values have decreased (e.g. Min. 1.0%, Karangoda; Max. 4.4%, Kahawatta; average, 2.04%) while at after phase has indicated with upsurges (e.g. Min. 2.3%, Haldola; Max. 5.4%, Kahawatta, average, 3.21%). Average degree and degree centrality have exemplified some of irregular patterns at three phases (table 4.4). For examples, average degree has increased from before phase (e.g. 0.92 with Min. 0.87, Haldola; Max. 1.066, Amuwala) to during phase (e.g. 0.94 with Min. 0.632, Kahawatta and Max. 1.275, Karangoda) and then has increased at the after phase (e.g. 1.52 with Min. 1.269, Karangoda and Max. 1.829 Raddella).

And also some of different patterns can be observed in some GNDs, for instance, Dambuluwana, 1.042, 0.957, and 1.523 at before, during, and after phases respectively. On the contrary, degree centrality has decreased from before phase (e.g. 19.86% with Min. 10.3%, Samangama and Max. 28.5%, Haldola) to during phase (e.g. 14.69% with Min. 8.2%, Samangama and Max. 20.5%, Dambuluwana, table 4.4). Despite, the degree centrality of after phase is lower than the before phase. This is because, at the after phase, many actors are possible to be identified with providing reciprocal supports. This can be identified clearly by looking the network topologies of after phase (e.g. Figures, 4.7, 4.8, 4.9, 4.10).

In particular, many actors are appeared at the after phases evolving of network topologies from more centered form (before phase) to more distributed form at after phase. Even at the after phase, the networks relations among households are not appeared at much dense form, but higher than compared to the before and during phases. This is because, they have helped to neighbors (in other words help to nearby houses) while they cleaning and preparing their houses. Mainly others who came for reciprocal supports have helped many ways in their capacities to make households and their premises better places for living. In particular, according to the respondents, many medical officers and health services also reported after phase compared before and during phases. This may because, after flood inundation a range of diseases mainly fewer reported with the mudded and contaminated environment. According to the respondents, at least one month time need to become to the normal condition of their premises and surrounding environment. Therefore, dense reciprocal ties and supports mobilizations at after flood inundation events make the verse situation more reduced and convenience for reviving livelihoods. The villagers of inundated villages and their supporters know very well the consequences and the difficulties that are incurring with flood disasters. By contrast, the support flows have been shaped the adversely affected livelihoods better by all the means, in particular for the areas like Elapatha GNDs in which undergone with the highest depth and duration of flood inundation.

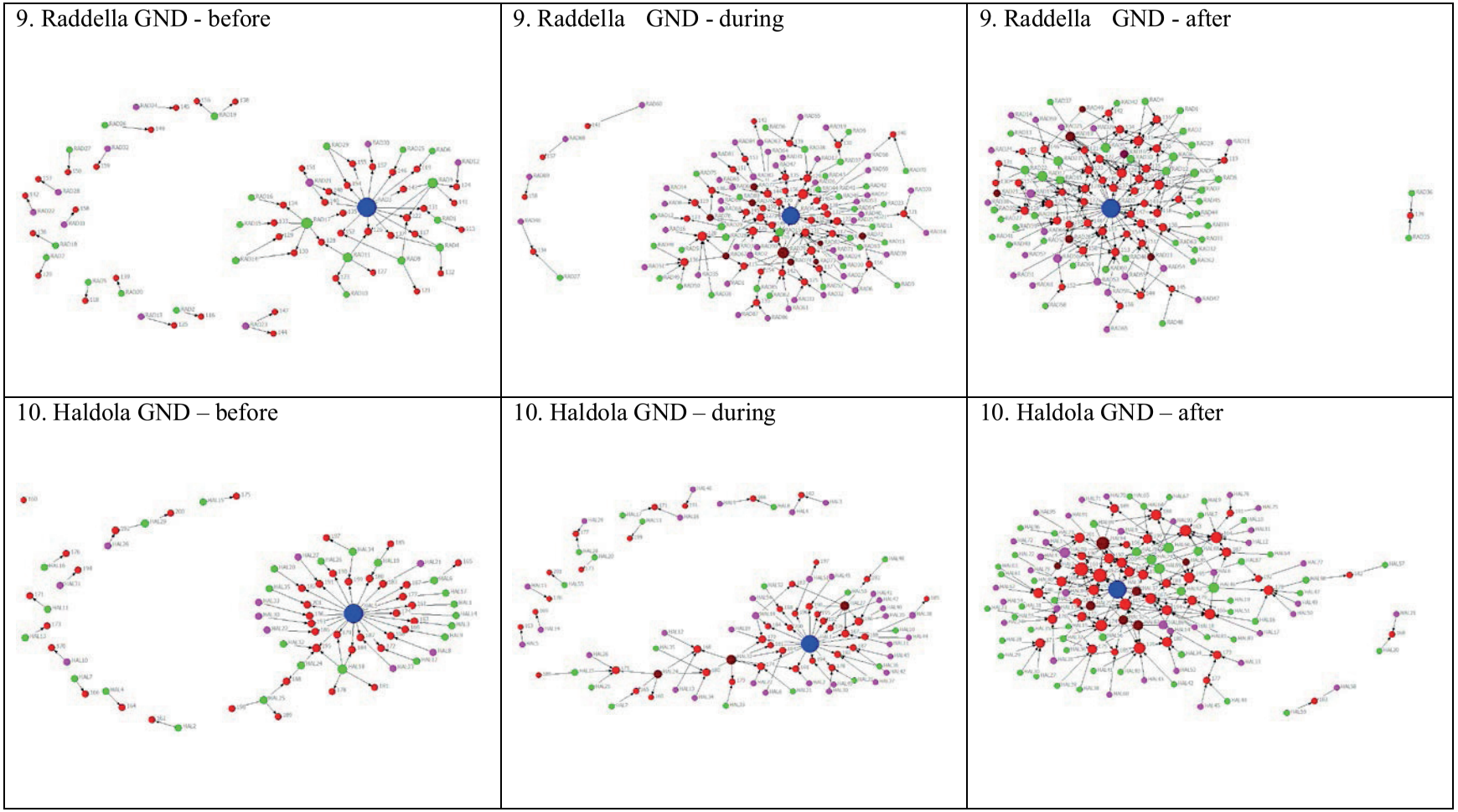

Figure 4.7: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Raddella and Haldola GNDs. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

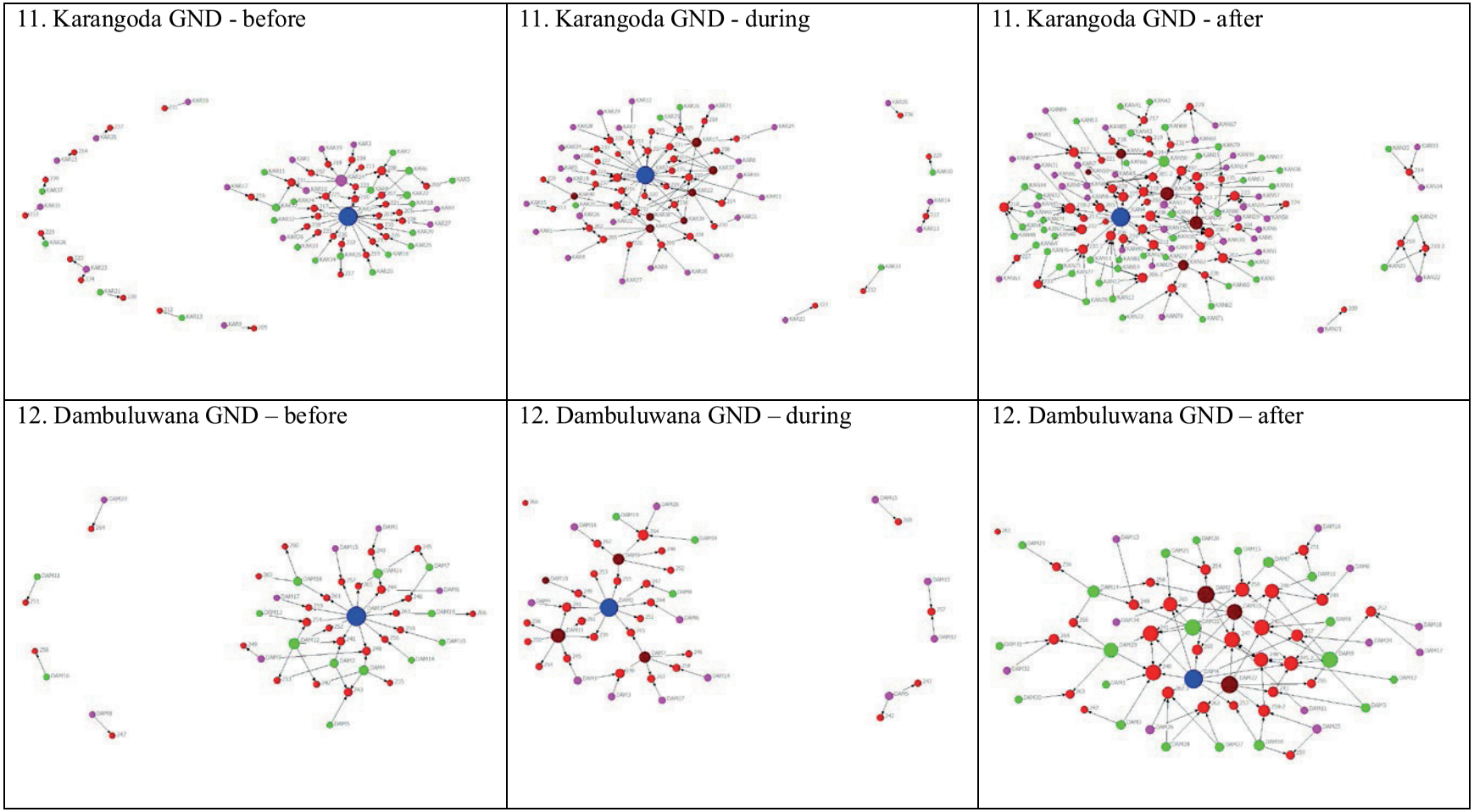

Figure 4.8: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Karangoda and Dambuluwana GNDs. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

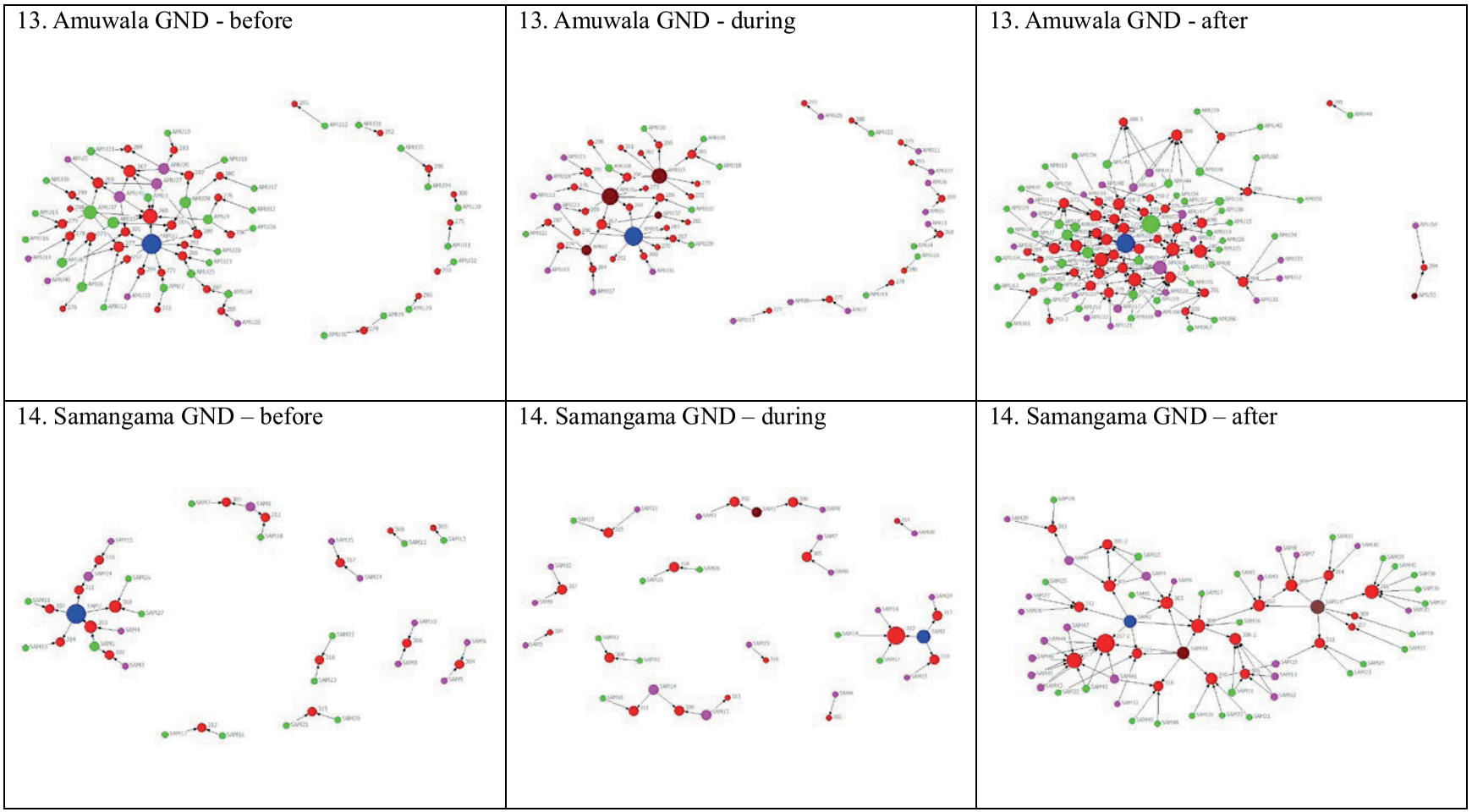

Figure 4.9: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Amuwala and Samangama GNDs. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

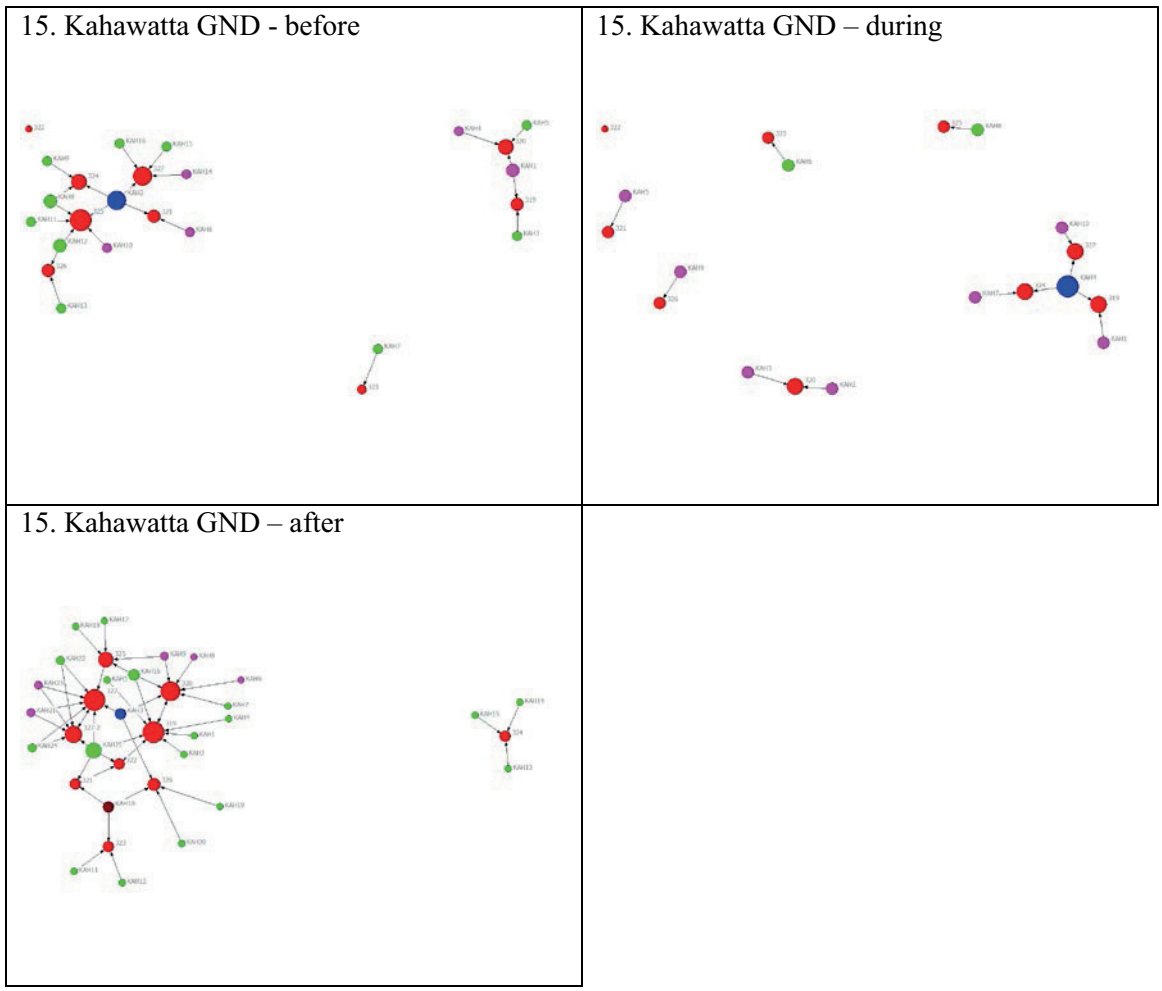

Figure 4.10: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Kahawatta GND. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

Figures 4.7 – 4.10 illustrate the dynamic nature, evolutionary and spatial patterns of socio-economic networks in sampled GNDs of Elapatha DSD. More importantly, structural changes of networks graphs are seen at three different phases. In particular, at before and during phases in all the GNDs, their network structures are shown with more clustered or with more subgroups nature compare to the after phase. Especially, as described earlier in detail, at before phase, all the HHs (who are inundating) have been trying to evacuate with their important belongings as soon as possible (e.g. at their earliest) before rush floodwaters into their HHs. At this juncture, some of helpers (mainly, neighbors and friends,

relatives are also if available) are supported firstly to their known HHs and then to others. Sometimes, they do not have time to go for other HHs. This nature is made their networks with more clustered or subgroups. They urged that they didn't contact with GNOs at before phase. On the other hand, mainly GNOs together with helpers are trying to support for inundating HHs which is generally created another whole network group(s) at before phase (Fig. 4.7-4.10). In accordance with the respondents' views, neighbors and friends are the majority among helpers at before phase (similarly at after phase too). At during phase, clusters are formed due to two main reasons. One reason is some of HHs members are stayed at their relatives' places. In some cases, many families are stayed at the same house. Others are may be neighbors and friends of them. The second reason is they didn't contact mainly with GNOs at during phase, may be due to many factors. For instance, at the GNO's end, it is impractical to support all the inundated HHs (e.g. located in own GND) at same time and also they do as much they could be. The rest of HHs members are stayed at common evacuation centers (e.g. Temples, schools, community centers tec.). Generally, GNOs have been contacted with these centers rather than other none inundated houses (e.g. in which other families are stayed). Generally volunteers are also contacting with these centers. This notion doesn't make sense that the helpers (including GNOs) have only been contacting with common centers at during flooding. Despite, some of few clusters are seen even at the after phase in some of GNDs, for examples, Haldola, Karangoda, and Amuwala etc. This may be, few of them have urged that no one helped them except their relatives. Samangama GND also can be identified as a special case, because of almost all the sampled HHs pointed out that they stayed at their relatives places during flooding and many of them even have same surnames.

Interestingly, the socio-economic network structures have become more distributed form at the after phase in almost all the GNDs in Elapatha DSD. This is because, as explained earlier, a range of reciprocal supports are mobilized at this phase and many actors are being linked with HHs in terms of cleaning and moving in activities in plenty. This is because, my personal view is that at the after phase, there is a greater likelihood to exist more dense reciprocal support networks (including goods and services exchanges) especially in those rural areas than they explained. Some of them often try to convince that they didn't receive many things like others and therefore please give us more, if you are going to give us some supports like aids. This nature is very general at many interviews. Some of isolated HHs also are seen in the networks graphs analysis (e.g. Fig. 4.7, Kahawatta, at before and during; Fig. 4.7- 4.9, Haldola, at before; Fig. 4.8-4.10, Dambuluwana, at during and after). They responded that no one helped them at related to those phases.

4.1.3. Colombo DSD – reciprocal supports and socio-economic networks

Regarding the Colombo DSD, 78 inundated HHs were surveyed whose are belonged to informal settlements among six GNDs. Figure 4.11 shows that the different collaborative supports (average) received by sampled HHs. Regarding the before phase, provision of information , evacuation, and moving out belongings are indicated 94.9% (with Min 82.6%, Bleomendal and Max 100%, Mahawaththa, Sammanthranapura, Mattakkuliya, and Modara; see, Appendix 1, Table A-1). Fewer percent reported in provision of food, other basic needs, and emotional supports (e.g. 5.1%; with Min 13.2%, Madampitiya and Max 17.4% Bleomendal) at before phase. This is because a majority of them have evacuated before flood inundation according to sampled HHs information. More importantly, none of provision of shelters is indicated at before phase. In during phase, provisions of foods, water, basic needs, shelters, and emotional supports are very crucial (e.g. 92.69%; with Min 77.5%, Madampitiya and Max 100%, indicated four GNDs). Provision of information and evacuation are accounted lesser per cent (e.g. 7.31%; with Min 0% in four GNDs and Max 22.5%, Madampitiya). Especially, arranging public places (e.g. public schools, temples, churches, and community centers) as evacuation centers for staying by GNOs and some of members of parliament (MPs) are also identified as the provisions of shelters. Particularly in the after phase, all the supports are represented as 100% with no financial supports. All the respondents urged that they didn't receive any types of financial supports for flood damages. Despite, admin authorities mentioned that they provided necessary aids for flood victims.

Table 4.5 illustrates the collaborations of network actors over different flood inundation phases. In related to the before phase, relatives are identified as main supports in all the GNDs except Bloemendal (e.g. 57.18%; with Min 25%, Bloemendal and Max 75%, Mahawaththa as well as Mattakkuliya). Secondly neighbors and friends are important (e.g. 32.02%; with Min 0%, Mahawatta and Max 66.67%, Bloemendal) and government officials and volunteers are recognized the lesser per cent (e.g. 10.8%; with Min 0% Modara, Mattakkuliya and Max 25% Mahawaththa). In during phase, admin officials or volunteers are identified as the main supports (e.g. 85.94%; with Min 49.1% Bloemendal and Max 100% in four GNDs). This is because majority of flood victims have stayed at evacuation centers (e.g. community centers) during flood inundation. Relatives (e.g. 11.28%; with Min 0% in four GNDs and Max 34.23%, Bloemendal), neighbors and friends (e.g. 2.78%; with Min 0% in five GNDs and Max 16.67%, Bloemendal) are identified as rest of helpers.

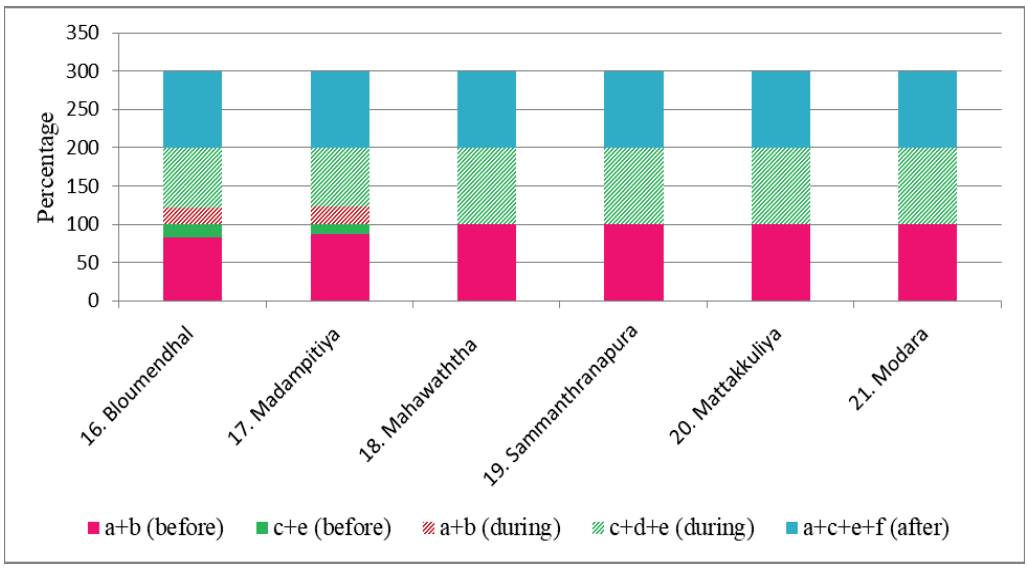

Figure 4.11: Reciprocal supports that HHs received at before, during, and after flood inundation, Related to Colombo DSD (for data; see, Appendix 1, Table A-1).
Notes: a- information provision; b- evacuation and moving out belongings; c-food, water and other basic needs including health supports; d- provision of shelters; e-emotional supports; f- move in back belongings of HHs, cleaning contaminated (e.g. mudded) HHS and public places.
Source: Own HHs survey, 2018/2019.

In after phase, relatives (e.g. 43.1%; with Min 33.33%, Modara and Max 50%, similarly in Mahawaththa and Mattakkuliya) and neighbors and friends (e.g. 35.06%; with Min 25%, Mahawaththa as well as Mattakkuliya and Max 33.33%, Bloemendal) have played major supportive roles while admin officials and volunteers are have made considerable collaboration in supporting them (e.g. 21.93%; with Min 14.29%, Madampitiya and Max 33.33%, Modara, table 4.5). All the sampled GNDs of Colombo DSD are represented quite different patterns of reciprocal helps which have discussed elaborately in the next section.

This study considered the informal settlements of Colombo DSD (flood inundated) for demographic and socio-economic network data collection. I personally observed and experienced that many differences regarding their network behaviors as well as their socio-economic characteristics compare to the rural contexts during my field visits. Due to many immoral, illegal, and underworld activities in urban informal settlement areas, the societal collaboration and socio-economic ties with other settlers have been eroded and much distrust in all the means among dwellers are seen. On this background, the socio-economic network measures are exemplified with quite different forms.

Table 4.5: Changing patterns of involved network actors over time (before, during, and after) (%), Related to Colombo DSD.

GNDs	Before			During			After		
	A	B	C	A	B	C	A	B	C
16. Bloemendal	8.33	25	66.67	49.1	34.23	16.67	19.05	47.62	33.33
17. Madampitiya	15.65	51	33.35	100	0	0	14.29	42.86	42.86
18. Mahawaththa	25	75	0	100	0	0	25	50	25
19.Sammanthranapura	15.5	52.1	32.4	100	0	0	14.6	34.4	51
20. Mattakkuliya	0	75	25	66.67	33.33	0	25	50	25
21. Modara	0	65.2	34.8	100	0	0	33.33	33.33	33.33
Average	10.80	57.18	32.02	85.94	11.28	2.78	21.93	43.01	35.06
Sectorial Average									
Rural	7.48	33.40	59.12	12.55	62.02	25.43	9.34	39.49	51.17
Urban / Colombo	10.80	57.18	32.02	85.94	11.28	2.78	21.93	43.01	35.06

Notes: A - Admin officials and volunteers; B – Relatives; C - Neighbors and friends.
Source: Own HHs surveyed, 2018/2019

Table 4.6 shows that the spatial and temporal patterns of socio-economic network measures related to sampled GNDs. All the key measures (e.g. degree density, closeness, and betweenness centralities) have increased from before phase to during phase and then decreased at after phase. For instance, at before phase, the degree density (average) indicated as 0.05 (with Min. 0.012, Bluomendal and Max. 0.067, Mahawatta as well as Mattakkuliya) and then at during phase, 0.08 (with Min. 0.02, Bluomendal and Max. 0.125, Mahawatta), while at after phase, 0.06 (with Min. 0.015, Bluomendal and Max. 0.10, Mattakkuliya). The closeness centrality scored 22.47% at before phase (with Min. 13.74%, Bluomendal and Max. 36.74%, Modara) and at during phase 33.09% (with Min. 19.33%, Bluomendal and Max. 39.31%, Mahawatta), while at after phase indicated 24.91% (with Min. 10.23%, Bluomendal and Max. 34.5%, Mattakkuliya). The betweenness centrality, recorded at before, during, and after phases as 2.55% (with Min. 0.5%, Bluomendal and Max. 5.56%, Mahawatta), 11.87% (with Min. 2.44%, Bluomendal and Max. 23.81%, Mahawatta), 5.23% (with Min. 1.4%, Mahawatta and Max. 8.26%, Madampitiya) respectively.

Table 4.6 : Spatial and dynamic nature of the Network measures related to before, during, and after flood inundation, Colombo DSD

GNDs	Before flood inundation					During flood inundation					After flood inundation				
	D	Ad	Dc (%)	Cc (%)	Bc (%)	D	Ad	Dc (%)	Cc (%)	Bc (%)	D	Ad	Dc (%)	Cc (%)	Bc (%)
16. Bluomendhal	0.012	0.523	10.9	13.74	0.50	0.020	0.744	42.3	19.33	2.44	0.015	0.755	10.5	10.23	1.83
17. Madampitiya	0.030	0.636	12.4	18.14	3.96	0.061	1.105	42.8	37.22	10.36	0.051	1.130	49.1	32.97	8.26
18. Mahawaththa	0.067	0.600	19.4	22.24	5.56	0.125	1.000	48.2	39.31	23.81	0.067	0.600	19.4	29.18	1.4
19. Samman thranapura	0.042	0.625	18.1	19.52	1.91	0.066	0.857	46.2	27.94	3.75	0.046	0.688	25.2	22.12	4.58
20. Mattakkuliya	0.067	0.600	19.4	24.46	2.77	0.111	0.889	33.9	36.92	26.2	0.10	0.900	56.9	34.5	8.05
21. Modara	0.055	0.545	17.8	36.74	0.60	0.10	1.000	61.1	37.8	4.66	0.091	0.909	13.3	20.48	7.27
Average	0.05	0.59	16.33	22.47	2.55	0.08	0.93	45.75	33.09	11.87	0.06	0.83	29.07	24.91	5.23
Rural	0.030	0.955	23.43	19.14	4.03	0.025	0.92	20.93	16.26	3.02	0.04	1.74	19.71	25.54	6.16
Urban/ Colombo	0.05	0.59	16.33	22.47	2.55	0.08	0.93	45.75	33.09	11.87	0.06	0.83	29.07	24.91	5.23

Notes: D= Degree density; Ad = Average degree; Dc= Degree Centrality; Cc = Closeness Centrality; Bc = Betweenness Centrality; All the Dc and Bc values are normalized.

Despite, regarding the betweenness centrality, Mahawatta GND scored the highest at both before and during phases and then the lowest at after phase. This may because, at during phase, the network structure shows with almost more centered form and then it has become to a more sparse form/distributed at after phase (e.g. Figure 4.9-19). All in all, Bluomendal GND exemplified with lesser measures while Mattakkuliya demonstrated with higher measures compare to the rest of GNDs (table 4.6), in particular due to small sizes of networks topologies. According to table 4.6, similarly, the average degree has increased from before phase (e.g. average 0.59, with Min.0.523, Bluomendal and Max. 0.636, Madampitiya) to during phase (e.g. average 0.93, with Min. 0.744, Bluomendal and Max. 1.105, Madampitiya) and again decreased at after phase (e.g. average 0.83, with Min. 0.6, Mahawatta and Max. 1.13, Madampitiya). The degree centrality also is augmented from before phase (e.g. average 16.33%, with Min. 10.9%, Bluomendal and Max. 19.4%, Mahawatta) to during phase (e.g. average 45.75%, with Min. 33.9%, Mattakkuliya and Max. 61.1%, Modara) and then reduced at after phase (e.g. average 29.07% with Min. 10.5%, Bluomendal and Max. 56.9%, Mattakkuliya). All in all, the socio-economic networks measures are quick high in all the GNDs of Colombo DSD due to the small sizes of ties (e.g. with lesser amount of actors) and the reasons have discussed in detail in the next section (in network graphs analysis section).

Figures 4.12 to 4.14 illustrate the spatial and temporal patterns of socio-economic network graphs in related to Colombo sampled GNDs. The structures of graphs are determined by the nature of reciprocal supports. In other words, the forms of graphs solely depend on the nature of reciprocal ties. In particular, regarding the Colombo informal settlement areas, dense reciprocal ties are not observed. Nevertheless, the network measures are indicated with quite larger figures due to the smaller sizes of networks. More importantly, each and every GND exemplified with more clustered or subgroups network structures at all the phases except very few cases (e.g. Figure 4.12, Madampitiya-during and after; Figure 4.13, Mahawatta-during; and Figure 4.14, Mattakkuliya-during). By contrast, Madampitiya at before/during (figure 4.12), Mahawatta at during (figure 4.13), and Mattakkuliya-during (figure 4.14) are typified with quite knighted ties. And also, graphs analysis shows that lesser subgroups formed at during phase compare to the rest of phases. This may because many of urban informal settlers have stayed at community centers during flood inundation events and they have experienced some of opportunities in which being interlace with others or volunteers.

Another important notion revealed by graphs analysis is that the isolated households. Many of respondents are urged that they didn't receive any kinds of

reciprocal supports, in particular at before phase. All the GNDs are indicated with one or more isolated HHs. Especially, Bluomendal GND (figure 4.12) illustrates that the highest numbers of isolated HHs at its three of phases compare to the rest of GNDs. For example at before, during and after phases indicated with 13, 8, and 7 isolated HHs respectively. Madampitiya GND also (figure 4.12) shows 6 isolated HHs at before phase and the rest of GNDs with two or less. A range of reasons are found behind this isolation during the HHs survey mainly due to some of their inherent situations at informal settlements and societal activities as described earlier in details. By analyzing the facts that observed by the field visits and focus groups interviews made with them, on the one hand, their some of day today behaviours have been make them isolate from others. On the other hand, others have separated from them due to possible harmfulness with contacting with them. In the socio-economic network sense, isolation makes many disadvantages in terms of reciprocal supports in particular in adverse situations.

Regarding all the GNDs (rural and urban), it is observed that the after inundation phases of many of figures illustrate the decentralized flood response and recovery network patterns. Particularly, this network topology is observed in the after phase in many GNDs. This network topology is more related to the distributed network topology with greater exponential degree distributions (Newman, 2010). A range of reciprocal support connections (in rural areas) can be found in the after phase as described earlier. Therefore, supporters are tied up with many households and the network topology becomes more dispersed. Regarding the numbers of actors and their connections, geographically diverse patterns are illustrated. The existence of "structural holes" may influence the diversification of supportive networks among regions. Structural holes could occur due to the absence of connections to neighbors (Newman, 2010). In almost all the figures one or more structural holes can be found in flood disaster supportive networks. More structural holes may have negative impacts on the related nodes and networks because they imply a lack of connections. Conversely, structural holes are negatively correlated with network densities, because more actors with fewer connections make more structural holes (Malm *et al.,* 2017). This study found quite interesting patterns regarding the structural holes formation. In the rural network topologies, many actors are seen at after phase. This is because mainly for providing supports for resettling villagers. Network measures also increased due this reason at after phase. However, the numbers of structural holes also have increased at the after phase. The main reason for this situation may be due to many actors without saturated ties and connections with each other.

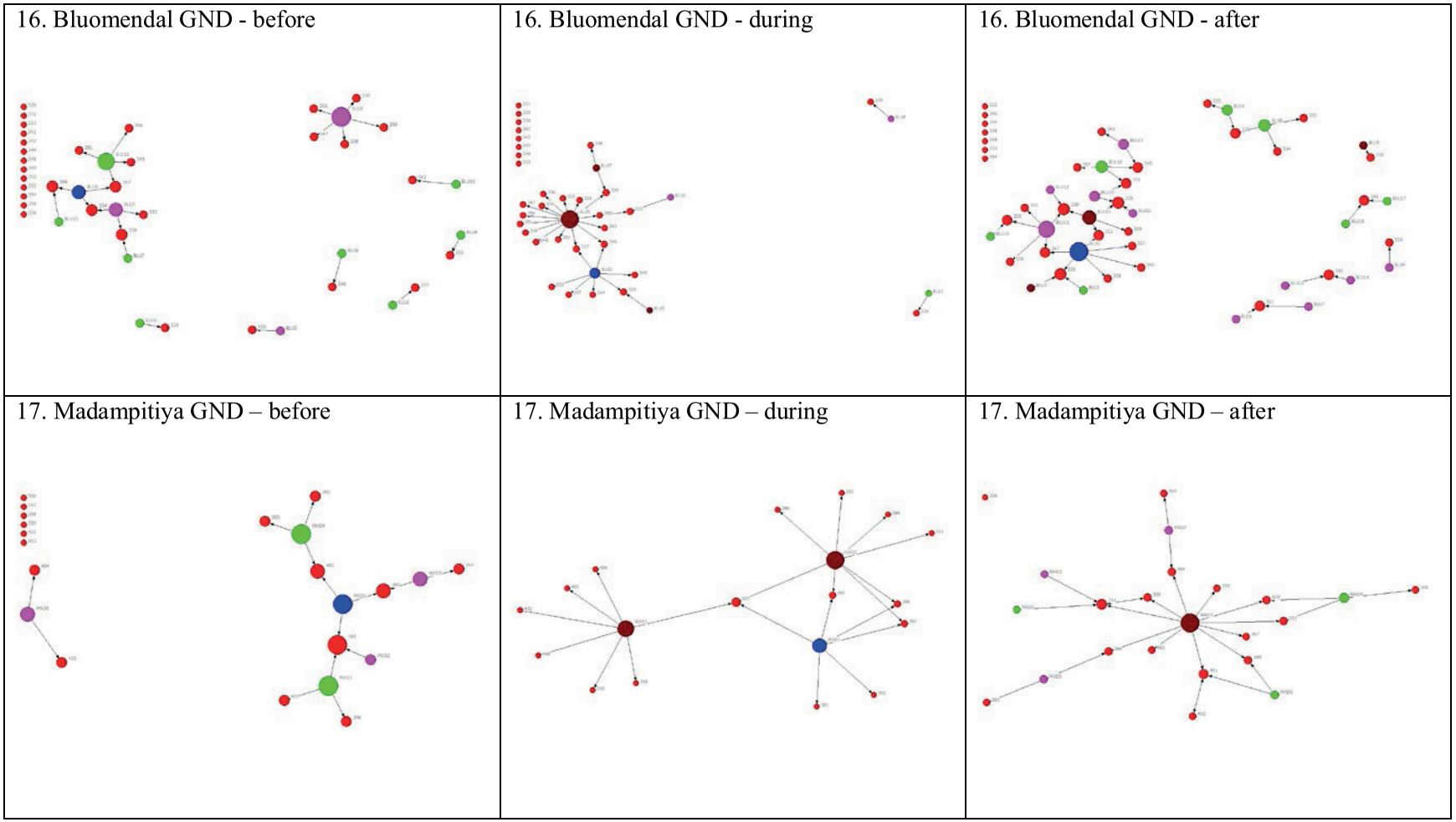

Figure 4.12: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Bluomendal and Madampitiya GNDs. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

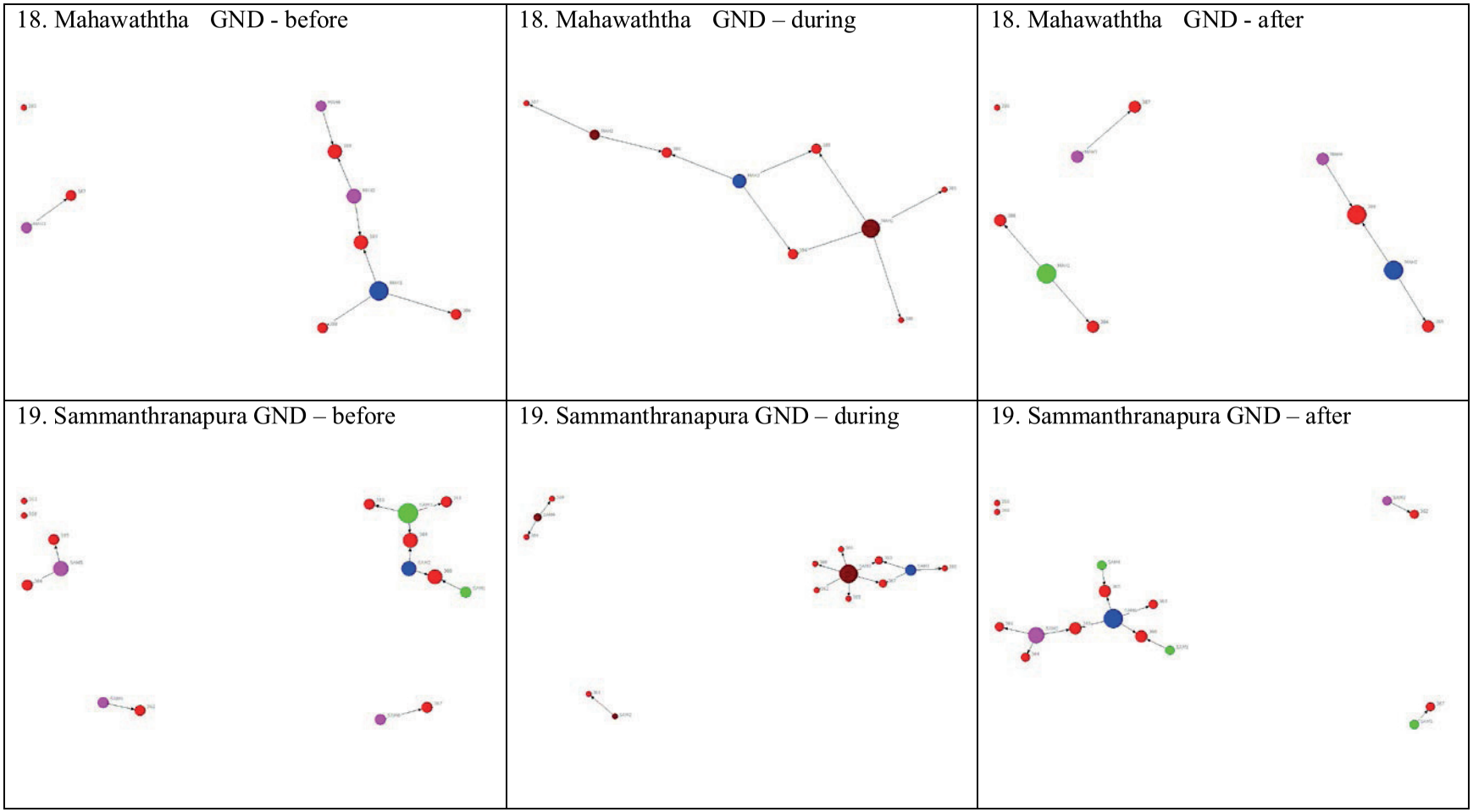

Figure 4.13: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Mahawaththa and Sammanthranapura GNDs. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

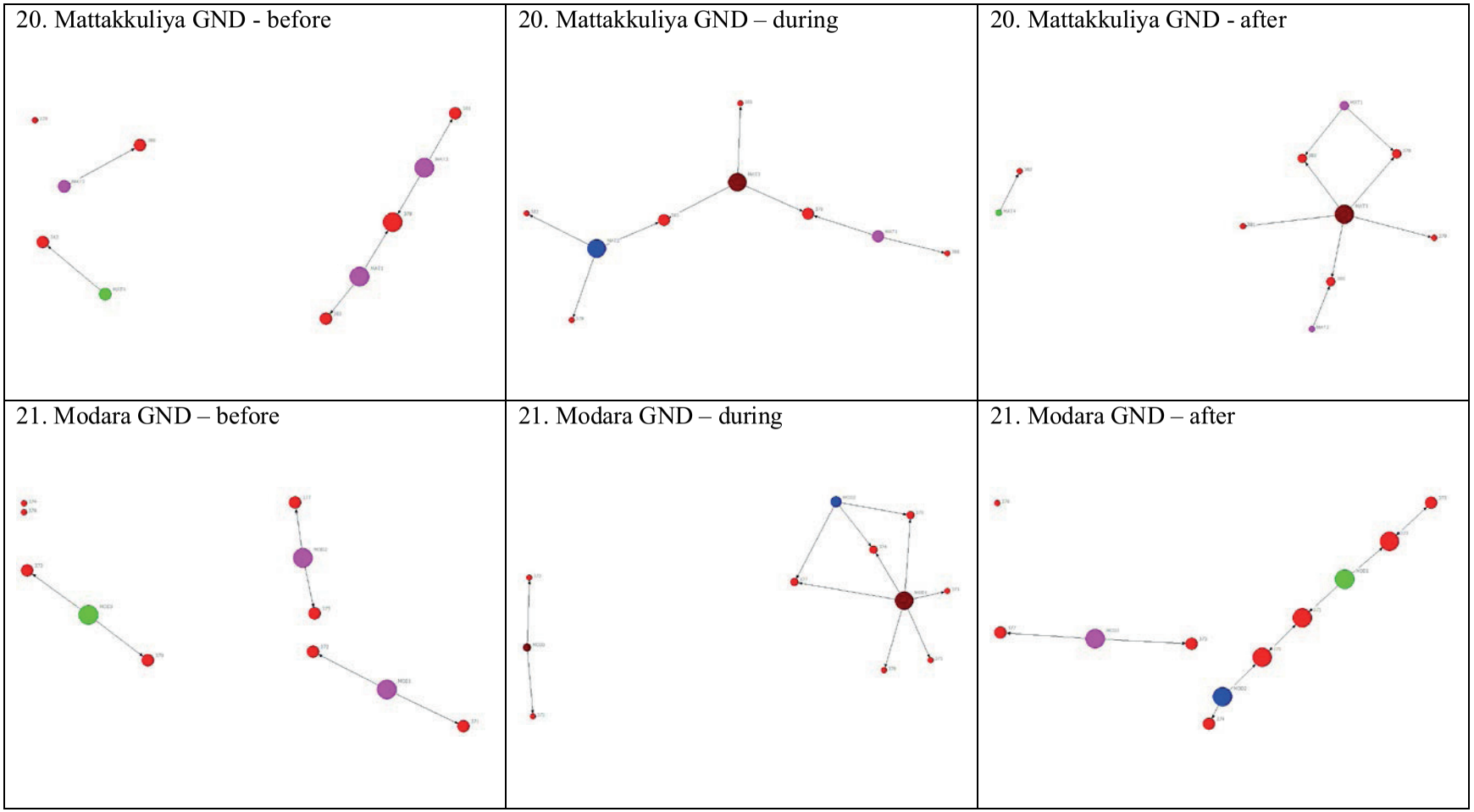

Figure 4.14: Dynamic nature and evolutionary patterns of socio-economic networks over time (before, during, and after flood inundation). In Mattakkuliya and Modara GNDs. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for surveyed households, Blue for GNO or authorities, Pink for relatives, Green for neighbors or friends, Brown for volunteers.*

4.1.4. Overall perspectives of empirical findings

Reciprocal support legacies

In a broader sense, the revealed results are proved that the considerable differences of reciprocal supports between rural and urban contexts as well as among regional geographical settings. It is obvious that the dramatic diversities are identified in related to the rural-urban dichotomy. In contrast, that is regarding the severity of reciprocal supports provision. Therefore, rural areas are exemplified with denser ties and rich reciprocal exchanges and supports mobilizations rather than urban areas. This can be clearly recognized by revisiting to the overall results of reciprocal supports.

More importantly, it is observed that quite similar narratives in reciprocal supports and resource mobilization in Kuruwita and Elapatha GNDs (rural) compared to urban GNDs. And also, fairly small changes can be seen within rural and urban contexts. For example, regarding information provision, evacuation and moving out belongings (items *a* and *b*), in Kuruwita, Elapatha, and Colombo DSDs repot 76.77%, 81.12%, 94.9% respectively with the rural average of 78.8% at before flood inundation (e.g. Appendix 1, Table A-1). Food and basic need provisions and emotional supports accounted as 8.93, 3.37, and 5.1 percentages in Kuruwita, Elapatha, and Colombo DSDs respectively while provision of shelters presented as 14.3, 15.51, and 0 percentages respectively in before phase. Provision of information, moving out belongings and evacuation are dominant in all the study areas at before phase. Despite, the provision of shelters not seen at before phase in Colombo GNDs as the majority of victims stayed at evacuation centers (e.g. Community centers). At during phase, provision of shelters, foods and emotional supports have been predominant in all areas. For instance, 79.55%, 82.3%, 92.69% are observed in Kuruwita, Elapatha, and Colombo DSDs respectively. Information provision and evacuation are very low at the same phase in Colombo (e.g. 7.31%), compared to Kuruwita (e.g. 20.45%) and Elapatha (e.g. 17.07%). More importantly, at after phase, provision of information (this is mainly on aids and repairing damaged houses and public places at after phase), foods, move in back belongings, cleaning contaminated households etc. are pivotal (e.g. Kuruwita, 94.14%; Elapatha, 92.7%, and Colombo, 100%). Despite, no financial support reported in Colombo sampled GNDs according to the respondents. Regarding the network actors, quite similar narratives observed in rural areas compared to the urban context. Some of regional variations are seen within both regional and urban areas as discussed earlier.

Strengthen social cohesion (and fabric), shared values, and trust have tightly been intertwined in the flood disaster events in terms of disaster preparedness and recovery. Recent studies have proved that more dense social collaborations, trust, cultural values, and reciprocal activities such as resources sharing and mobilizations have significantly been influenced to reduce the adverse consequences of natural disasters (e.g. Faas & Jones, 2017; Malone & Kinnear, 2015; Htein, Lim, & Zaw, 2018 etc.). All in all, social collaboration implies more weighted sense, in other worlds, bigger contribution of non-financial supports in terms of flood disaster preparedness and recovery especially in surveyed rural areas. This study demonstrated that provision of information; activities such as evacuation, moving out/in belongings from and to HHs; food, water and other basic needs including health supports; provision of shelters, emotional supports; cleaning contaminated (e.g. mudded) households and public places etc. have played a crucial role in flood disaster preparedness and recovery (e.g. Figures 4.1, 4.6). Particularly in the before phase, 'information provision', and 'evacuation and moving out belongings' represent predominant percentage in almost all the DSDs. Provision of food, basic needs, emotional supports, and provision of shelters (items *c, e*, and *d* respectively) indicated with low per cent in many regional areas and two urban areas at before phase (no item *d* seen in urban context in this phase as explained earlier). In during phase, item *c, d* and *e* scored with higher percentage in all the areas and with less percentage of items *a* and *b* in all inundated areas (also, no item *a* and *b* seen in some urban areas in 'during' phase).

Regarding during and after phases, a range of support reciprocal networks can be seen particularly in rural areas covering all the inundated GNDs. More strengthen reciprocal practices showed in the flooding events, can be identified as such a *de facto* tradition in particular rural Sri Lankan society rather than urban context. Especially, these traditions have long been interlaced with rich cultural heritages in Sri Lankan communities (e.g. Daskon & Binns, 2010; Karunarathne and Lee, 2019). Despite, in the urban context of Sri Lanka, these practices have been diminished rapidly. And also, in the after phase, *information, foods, emotional supports*, and *cleaning HHS are* depicted with greater proportion in all DSDs). Importantly, no financial supports reported in urban areas in accordance with the results of HHs survey. Despite, some GNOs who are belonged to urban areas urged at meetings, that they have made financial supports for flood victims. On the contrary, more than 95% of rural inundated HHs have received financial supports from government as well as from other donors. Basically, 10,000 rupees (55-57 $, according to current exchange rate) have provided for inundated HHs in Kuruwita and Elapatha DSDs by the government two weeks after the inundation as an advance in order to repair their HHs. The rest of aids have been paid after assessing

the damages. Regarding urban areas, respondents urged that they didn't receive any compensating aids from government after the inundation. Despite, many GNOs mentioned (the head of GNO of Colombo DSD also confirmed that) that the damage HHs were granted with some amounts of money up to 10, 000 rupees. In particular, the damages are quite impossible to be assessed in accordance with the conditions of HHs which are located in informal urban settlements.

In the after phase, forces members and the whole community have been engaged with greater efforts in order to revive island wide flood-affected livelihoods. For example, three to four Sri Lanka Civil Security Force members have stayed in all inundated GNDs in Kuruwita DSD and they have cleaned all the wells (private and public) and public places after the flood inundation. These supports are very influential in many ways for their livelihood revivifying efforts. Long-run flood inundations (e.g. 10 to 15 days in some cases) have made detrimental effects on the house conditions and safety. By contrast, the living conditions of households totally intolerable after the flood inundation events. For instance, majority of rural villagers urged that after 10 -15 days flood inundation, their HHs almost have contaminated with muds and they have to wait/stay for cooking for more than one week to lighting up their hearths after inundation (for whom still have been used firewood for cooking) and reciprocal supports is the only way (may be panacea for flood victims) to survive. In other words, livelihoods of flood-affected areas solely depends on reciprocal exchanges and mobilizations coming through the village socio-economic networks. This is because, from a cumulative sense, after flooding events, some rural areas become clearly 'depressed areas' economically as well as a low standing of living with bashing unemployment status (e.g. table 3.4).

Figures 4.15, 4.16, and 4.17 illustrate the respondents' overall feelings and rates on collaboration and helps that they experienced before, during, and after flood inundation phases. It is important to mention that some of controversial information have provided in particular by urban respondents and I tried to extract the exact and actual information as much as possible. By contrast, during interviews, different information and stories come out after 30 - 40 minutes of discussions compared to the facts that the same respondent reveled at the beginning of the interview. According to the 4.15, 4.16, and 4.17 figures, the majority of respondents have explained more positive responses and feelings on the reciprocal supports mobilized and that they received. As explained earlier, more strong and broad socio-economic networks experiences explored from rural areas rather than Colombo areas. Regarding the items A, B, C, and D, (figure 4.15, table A-2, appendix 1), the majority of rural respondents replied with strongly agree or agree. Therefore, their average response rate is less than 2 in rural areas except two GNDs,

for examples, Miyanadeniya (e.g. 2.28, item D) and Kahawatta (e.g. 2.0, item D).

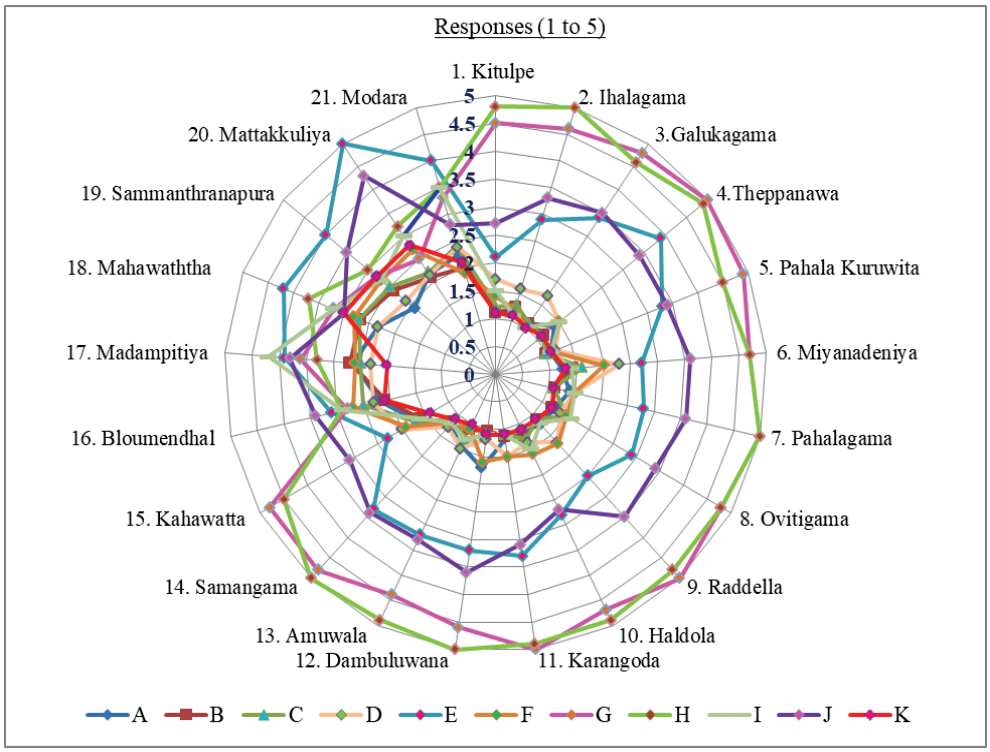

Figure 4.15: Respondents' overall feelings and rates on collaboration and helps before flood inundation / All GNDs (Relevant data are in Appendixes Table A-1).
*Notes: **A**. I received all the necessary information before the flooding; **B.** I received very good helps by friends; **C.** I received very good helps by neighbors; **D.** I received very good helps by the Government; **E.** I received very good helps by volunteers; **F.** Local authorities announced necessary information on right time; **G.** No one helped me; **H.** I did everything myself; **I.** I have strong trust about others on readying for flooding; **J.** I also helped my neighbors and friends to move out things before floods; **K.** We collaborated with others to overcome our difficulties.*
Responses: (1). Strongly Agree; (2). Agree; (3). Neutral; (4). Disagree; (5). Strongly disagree.

The average response rates in urban areas for the same four items are greater than 2 except Sammanthranapura GND (1.9, item A). Especially, some of dangerous events such as thundering and lightening have been very pervasive during torrential rains in study areas. This is because the frequent uses of radios or mobile phones are impossible.

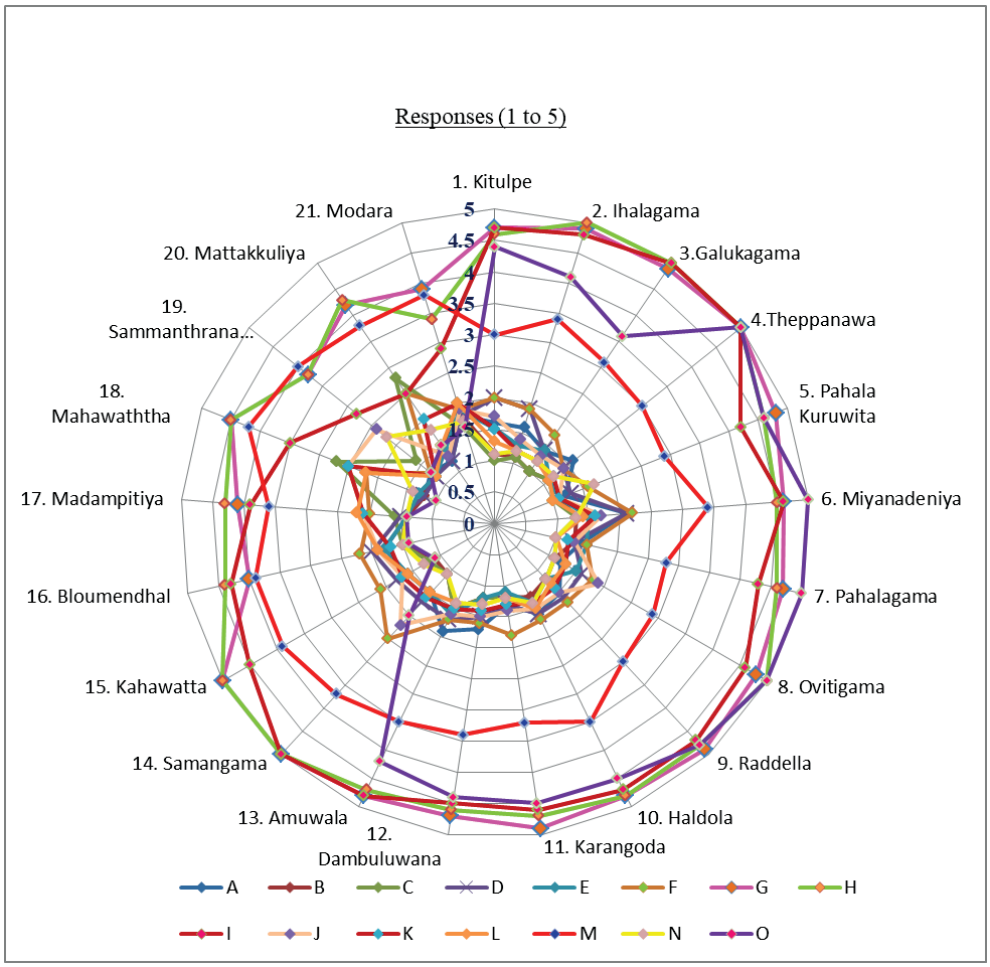

Figure 4.16: Respondents' overall feelings and rates on collaboration and helps during flood inundation / All GNDs (Relevant data are in Appendixes 1, Table A-3).
*Notes: **A**. I received all the necessary information on evacuation; **B**. I received very good helps by friends; **C**. I received very good helps by neighbors; **D**. I received very good helps by the Government and forces; **E**. I received very good helps by volunteers; **F**. Local authorities announced necessary information on right time; **G**. No one helped me; **H**. I did everything myself; **I**. I did feel run out food, water, and other basics need during the floods; **J**. I received all the basics needs during the floods; **K**. I have strong trust about others on evacuation flooding. **L**. My overall rate about helps rendered by other during the floods; **M**. I also helped my neighbors and friends to evacuate during floods; **N**. We collaborated with other to overcome our difficulties; **O**. We had alternative access roads to evacuate during the floods.*
Responses: (1). Strongly Agree; (2). Agree; (3). Neutral; (4). Disagree; (5). Strongly disagree.

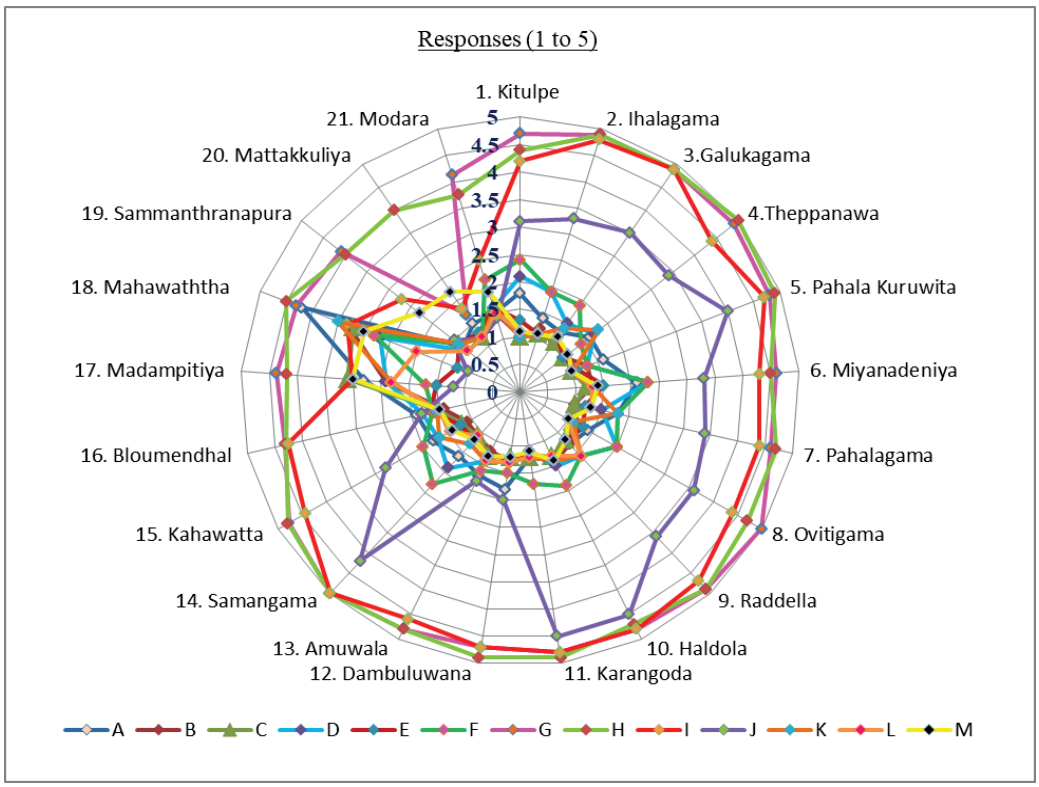

Figure 4.17: Respondents' overall feelings and rates on collaboration and helps after flood inundation/All GNDs. (Relevant data are in Appendixes 1, Table A-4).
*Notes: **A**. I received all the necessary information after the flooding; **B**. I received very good helps by friends; **C**. I received very good helps by neighbors; **D**. I received very good helps by the Government and forces; **E**. I received very good helps by volunteers; **F**. Local authorities announced necessary information on right time; **G**. No one helped me; **H**. I did everything myself; **I**. I did feel run out food, water, and other basics need after the floods; **J**. I am feeling, I have lost everything after flooding; **K**. My overall rate about helps rendered by other after the floods; **L**. I also helped my neighbors and friends to move in after floods; **M**. We collaborated with others to overcome our difficulties.*
Responses: (1). Strongly Agree; (2). Agree; (3). Neutral; (4). Disagree; (5). Strongly disagree.

Information dissemination, responses of friends and neighbors are very helpful not only for raising awareness on possible flooding events but also for making evacuation planning before reach the disasters. This is because the sharing information and collaboration for disaster response is pivotal important in terms of recovering from them (e.g. Jones and Faas, 2017). Information also is crucial at during and after phases of flood inundation, especially for meeting volunteer

services and victims (Figure, 4.16, 4.17). Regarding the item F, the provision of information at right time has been managed in particular by government (e.g. disaster management center = DMC), but generally urban respondents rated that between agree to neutral (figure 4.15) with some of deviations (see, appendix, table A-2). Volunteering also one of pivotal parts in disaster supports networks (e.g. Stewart, Glanville, and Bennett, 2014; Jones and Faas, 2017).

According to the results revealed, at the before phase, volunteering (item E, figure 4.15) activities (this means supporters from outside areas, but not relatives, neighbors or friends) have rarely been seen or absent. It is very obvious for the natural disaster like flood inundation. Therefore, majority of respondents in both rural and urban areas rated that above 3 or neutral to disagree (e.g. figure 4.15) while at during and after phases have much been volunteered (figure 4.16, 4.17). Conversely, Stewart, Glanville, and Bennett's (2014) research revealed that volunteering appeared before flooding event is being reached 40% according to respondents. The majority of respondents in rural areas rated at strongly disagree feeling for the notion of 'no one helped me' compared to urban respondents at before phase (item G, figure 4.15). In the after phase also similar narratives can be seen in both sectors with regional differences (item, G, figure 4.17). One of respondents (45 years old) living in Galkada village, Kuruwita GND explained her experienced on reciprocal supports received in the 2017 mass flooding event as follows;

"*We are, many families stayed at Mr. Vaidyasekara Jayalath's (businessman, in Galkada) house during 2017 mass flooding event. Generally he planned before possible flooding events and prepared his house with many foods including rice, and other necessary ingredients for curries. He welcomed all the flood victims of nearby areas and provided foods, sheltering and other basic needs during flooding for all. We also helped him many ways to manage facilities….*"

Quite similar narratives explained by one of respondents (54 years old) living in Dambuluwana GND, Elapatha, described his experienced during 2017 mass flooding event as below;

"…We are together, hundreds of flood-affected families from many areas, stayed at Dambuluwana Naga Pusparamaya Buddhist temple during flooding. Ananda Sagara himi and others (Buddhist monks) provided with us all the facilities including foods, water, sheltering and other basic needs in many ways. The temple arranged everything there including cooking for all…."

Many village level networks flows often exemplified as reciprocal exchanges and mobilization by the ways in which identified of being behind the recent flooding events particularly in 2017. All the donators almost worked through their networks have been made their donations for helping flood victims perhaps not expecting any 'quid pro quo'. One of very poor respondents (68 years old) in which said to be poorest of the poor, living in Dimiyawa village, Elapatha, explained her experiences on the immediate past flooding event (2017) as follows;

"…We are three of old people, including my husband, husband's unmarried sister and myself are living here. It was very hard to explain all the impediments we faced due to ferocious flood inundation. We lost our many of things including cooking hearths, the only way to survive is others' helps rendered following the event, We received many things foods, cloths, subsidies (Viyali Salaka from local authorities), they repaired and cleaned our damaged house, GNO also helped us many ways, we consumed couple of weeks with those foods and goods, we highly appreciate and acknowledge all the helps as those were very helpful for reviving our livelihoods…"

There is also evidence that the mental health of old-aged people have been fostering with the emotional helps. In contrast, they are very like to be with others in common places and sharing their past experiences and having other helps from network actors. Many of respondents also explained their experiences that supporters' efforts on flooding events have effectively been helped to reduce the damages to village lives. So far, the reporting of 'no casualty' along the known flooding history is the centerpiece of the prowess of village socio-economic networks. Village socio-economic networks have even been shown to be effective in other village level events such as funerals, weddings, religious activities etc.

However, at during phase, urban sector's respondents also rated with similar feelings (item, G, figure 4.16). This is because, urban respondents have received satisfactory supports at evacuation centers at during flooding compared to the rest of the phases. One of respondents (42 years old) living in Bloemendhal GND, Colombo explained her experiences on 2016 mass flooding event as follows;

"We stayed at a nearby evacuation center (a public school), many families stayed there, many of our family members lost our belonging during flooding, because they have stolen by some of "Kuddas"(gangsters who are using drugs like heroin), two members of urban councils gave us foods, water and helped us many ways, we didn't receive much from publics…."

Despite to the facts that GNOs of Colombo sampled GNDs explained that they managed to facilitate flood victims with everything during 24 hours even with some of NGOs which have explained in details in latter part of this chapter.

For the item H, also observed quite similar narratives in both sectors at during and before phases, while some different in before phase related to urban areas (item H, figure 4.15) with some of fairly differences in Miyanadeniya, Sammanthranapura, Mattakkuliya, and Modara at during and after phases. Almost rural villagers have strong trust on others on preparing for flooding compared to urban sector (item I, figure 4.15) while quite similar patterns observed on the trust on evacuation (item K, figure 4.16). Especially almost all the rural respondents explained that helping neighbors to move out their belonging before flooding while preparing their belonging to bring out is somehow difficult, albeit they help when they have chances to do so (item J, figure 4.15). Similar situations and also ratings observed in both sectors related to the item M (figure 4.16). On the other hand, the collaboration is very crucial and instrumental in rural areas compared to urban context (item *K*, figure 4.15). Of course the collaboration is the pivotal value of support networks in all the means (see, Jones and Faas, 2017; Scott and Carrington, 2012). Items *L* (figure 4.16) and item *K* (figure 4.17) also exemplify their overall rates on reciprocal supports. One of very crucial aspects reveals by figure 4.16, item *O* which is that the availability of alternative access during flood inundation. The majority of sampled GNDs of both rural DSDs (Kuruwita and Elapatha) have been encircled by floodwaters compared to sampled GNDs in Colombo DSD. Some of rural households located in GNDs like Ihalagama, Pahal Kuruwita, and Galukagama have alternative accesses during flooding events and that condition is not applicable to all the households. Moreover, items *L* and *M* in figure 4.17 also show respondents' ratings on the collaborations and more importantly networks actors have been working in compliance with their flood disaster rescue procedures in the flooding events. Therefore, village socio-economic networks' behaviors are very significant as they demystify the serious process and dangerous of flooding events. All in all, the regional network behaviors in the flooding events are in stark contrast to the urban networks behaviors is quite different a plenty of ways.

On the other hand, regarding the responses about local authorities, all the arguments have been more germane to the village level party politics discourse and villagers have often been urged that they should work together without meeting of political ends. Respondents and key actors of village socio-economic networks urged that their networks are very strong and have not been lose their rigidity due to political favorations. Because of the lopsided distributions of aids has been bringing big dissatisfaction among flood victims in some of GNDs. For examples, one of respondents (35 years old) living in Miyanadeniya GND, Kuruwita

explained his experience on lopsided favorations of flood aids as bellows;

"...We are in here many poor people adversely affected by flood inundation in 2017, we faced very bad and unfair experiences on flood-aid program, from the aid program the GNO provided much for the households who are belonged to his/her political party, we received less as we are belonged to an another party, actually some of our households have damaged very much compared to those who received much..."

This is because, *"....people might be more suggestable when consenting to and answering interviews, and it means that the information they share might be more sensitive than it would be in another settings...."* (see, Jones and Faas, 2017, P. 7). Responses revealed that some villagers were being underserved by the aids programs particularly due to the party politics and lopsided treatments and mostly under-resourced villagers claimed this. Mainly some of extrinsic factors such as party-politics impasses have been influenced to values and harmony among villagers. Dismal politicians often have been joined with the facilitation programs aiming at their forthcoming elections and even in the village infrastructure development projects and this can be seen as such an unfortunate situation.

According to the meetings held with officials of DSDs, I have found credible evidences for the excess of reciprocal supports made by public collections and individuals for flood victims. Kuruwita DSD office has been maintained a large room to store public donations by the ways in which received from different networks for flood victims (this is except to direct supports have provided for inundated HHs by public). Even after six months of flooding events that store has a range of durable goods such as clothes, shoes, school items etc. And also, villagers of many areas urged that they have been used, received/reciprocated donations during one or two months after flood inundation (foods, such as grains mainly dhal and rice, soaps, sugar, and fish tins etc.). Officials pointed that villagers termed "*PIN WATHURA*" for 'flood waters' due to a spectrum of supports in which they received. Because of, villagers are sensed that floodwaters as kind of 'fortune' or 'lotteries' for them. Therefore, socio-economic networks provide required impetus for resilience activities in all the means throughout villages. Respondents explained that the nature of resilience activities when the flooding events are unfolded. These narratives imply that the instrumental notion of social cohesion and reciprocal support networks on flood disaster preparedness and recovery and ameliorating flood vulnerability.

Moreover, an important aspect of regarding disaster response and recovery networks is that types of networks actors involved with the reciprocal supports

activities (Verda, 2017; Faas & Jones, 2017). This study also proved that the involvements of flood disaster supportive networks actors such as relatives, friends, neighbors, admin officials and volunteers have been evolved over the time (before, during, and after) and also have differed particularly among sectorial contexts as explained by figures. Especially, related to three phases, rural HHs have been received relatively higher percentage of helps from relatives, neighbors, and friends rather than admin officials and volunteers and the opposite patterns showed in the urban context (Figures 4.1, 4.6, and 4.11). Because of, on the one hand, a majority of urban flood victims have stayed in temporary evacuation centers. On the other hand, in accordance with urban interviewees' point of views, they don't have dense consolidation of ties among others may be due to their living status, a range of economic hardships and the scarcity of resourcefulness. And also, a range of underworld activities such as drugs trafficking, murdering and smuggling (e.g. many investigations undergo on heroin business) are common. The footloose nature of urban shanty's lives makes them involve with drug smuggling like heroines, dealing with illegal underworld works in plenty. This may because they explained a plethora of disputes among neighbors.

On the contrary, majority of rural HHs members have stayed at relatives and friends places, also in evacuation centers and have received many helps from others. Especially villagers have been used own made wooden boats or fiber boats that provided by Disaster Management Center (DMC) for evacuating and reciprocal activities. Sometimes, evacuation activities and moving out belongings from HHs have been stretched from before to during phases. And also, GNOs and volunteers including forces members (Army, Navy, and Air force) have played a pivotal role in coordinating and managing flood preparedness and recovery activities in both the sectors. At the after inundation phase, the predominant actors are neighbors, friends, and volunteers in both the sectors with some amount of dissimilarities especially in urban areas. In the villages, some families are stayed at their own homes if they have upper stores (only if upper floors are not being inundated) and some old houses in which they have wooden upper part called '*SOLDARAYA*'. That is one of instrumental traditional practices which have been used since many decades for flood disaster preparedness and recovery and has explained in detail in the next section. Some urban dwellers pointed that they also have stayed on wooden tables during flooding events only if the inundation depth is very low (less than 3 to 4 feet).

More importantly, it is obvious that the overall responses of flood victims on reciprocal supports that mainly mobilized and volunteered also are belonged to bridging, bonding, and linking social capital. By contrast, it is quite difficult to distinguish social capital metaphors from socio-economic networks. In other words,

social capital has been building and mobilizing through socio-economic networks. Therefore, section 4.2.3 of this chapter also presents the general overview of social capital (considering their day today life) in affected GNDs by contrast to the rest of sections of this chapter. Figure 4.18 briefly depicts the findings of this study on how socio-economic networks and social capital matter to reduce stresses, pressures, and perturbations while improving victims' adaptive capacity as a mechanism. Especially, their altruistic natures of helping others and related shared and moral values have tightly been intertwined with traditional cultural and knowledge practices of Buddhist societies as most egalitarian elements.

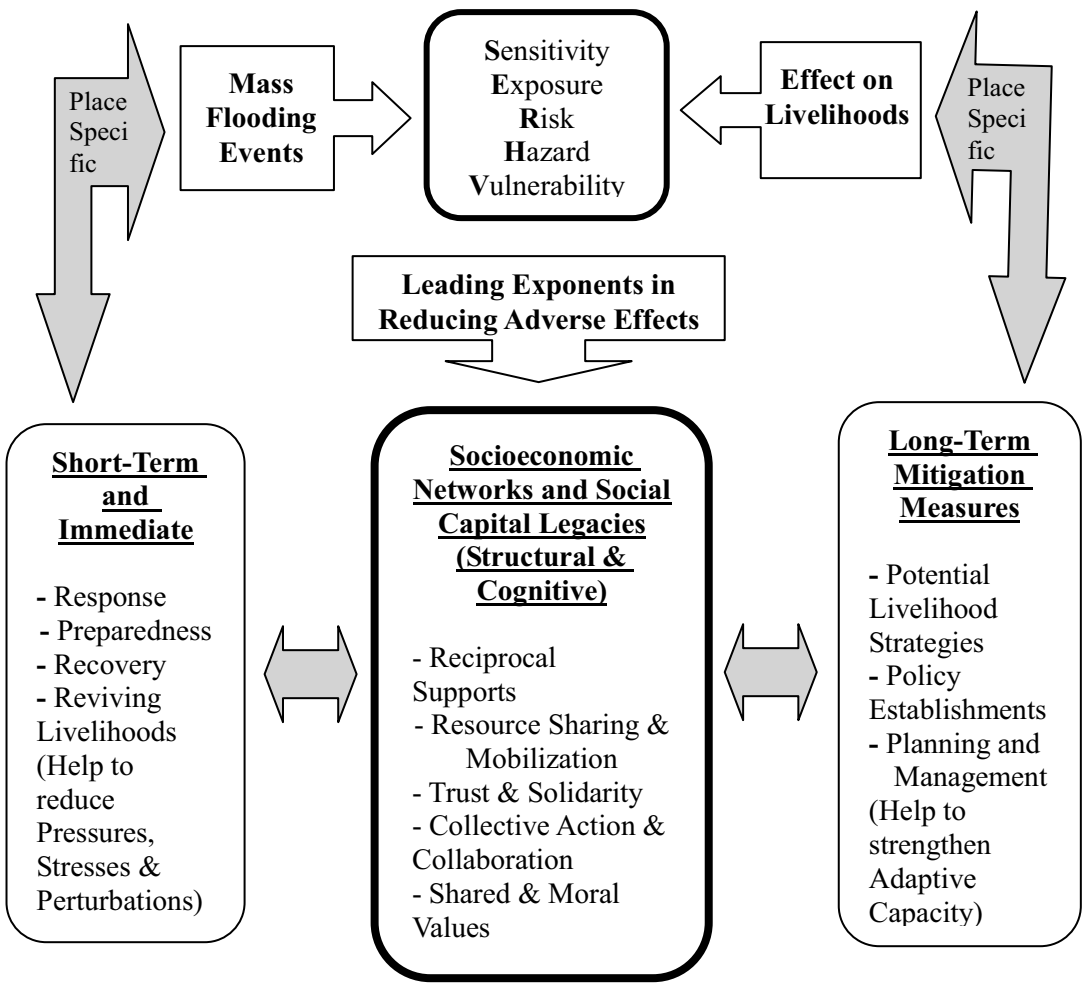

Figure 4.18: Socio-economic Networks and Social Capital driven Social Vulnerability Ameliorating Mechanism.

Figure 4.19: Different reciprocal supports; upper left panel-GNO investing the evacuation (Ovitigama); upper right panel- evacuation supports in Raddella during flooding; bottom left panel-moving out belongings during flooding in Pahalagama; bottom right panel- cooking collaboratively for victims in Pahalagama. Source: Field observations

The study found that some of active network actors have been working hard and their persistence and enthusiasm have shaped and improved the strength of socio-economic networks. And also, even many GNOs, for examples, Ovitigama and Pahalagama GNDs (Kuruwita DSD) and Raddella GND (Elapatha DSD) have been played a pivotal role in managing and providing facilities to their flood affected people. Figure 4.19 illustrates the reciprocal activities during flooding events.

Therefore, village socio-economic networks are more instrumental even in the places where which with rugged terrain settings are existed. At some particular flood inundation events, it's unbelievable and hard to envisage how they have been providing their end-to-end services, riding boats with very high inundation depths throughout villages. On the other hand, some situations are very sensitive and dangerous, e.g. doing evacuation and move out activities while the floodwaters are being rushing into their houses concurrently. Reciprocal exchanges have been evolved from past as traditional customaries along decades of years and may be basements for the establishment of socio-economic networks. These practices are being persisting yearly as they have omnipresent qualities in plenty. Also, some of respondents ensured that helping each-other in the flooding events and aftermaths may be significant practice to change the monotonous village life. Some actors explained that they have used their experiences and nimbleness in order to help more and more people in the flooding events. In other words, village networks' efforts often strengthen to the emancipation of a plenty of flood victims in villages. By contrast, Reciprocal exchanges and resources of socio-economic networks are endowed by villagers to their networks. Generally, during flooding events, outsiders (helpers and volunteers) have been used boats to distribute foods (in particular lunch and dinner parcels) and other basic needs for flood victims (e.g. figure, 4.19).

Some gem businessmen (e.g. in both Kuruwita and Elapatha DSDs) also have been doing many social supports following flooding events, with their lure of financial assistants. Also, some gem businessmen have appointed as advisers and funders of socio-economic networks, following their lures of fame, particularly including money. Also, village socio-economic networks seem prudent to be continued and have gaining momentums for further enrichments. Some actors are very busy with their occupations and external activities, despite they provide their supports (resources and financial) for the networks. Some of respondents point that socio-economic networks would not put the livelihood at risk and they have much enough confidence on their activities. Because of, even modern socio-economic networks are financially prudent and egalitarian in reciprocal exchanging. On the other hand, village socio-economic networks and their egalitarianism have

consolidated more trust among actors in the village networks system. Egalitarian nature by contrast, is treating and helping others in an unbiased manner, is customary practice of villagers in sampled rural areas. Egalitarian networks have been become omnipresent icon of reciprocal activities throughout villages and rural life styles the ways in which villagers safer from outside shocks and encounters. Respondents highlighted that the strenuous efforts in helping each other, can be seen during the flooding events throughout villages. The cultural values, norms, and customs have been stimulated the egalitarian activities of rural socio-economic networks. These tangible evidences stimulate villagers to do something for other similarly in the disaster events. It has even been shown that egalitarian networks are very effective in normal day-to-day lives of villages. Therefore, village socio-economic networks and their egalitarian nature, possible to be used as a centrifugal force for future development trajectories of rural areas and villages as well. Their socio-economic associations (detail explanation exists in the next section) have established their own rules and regulations aiming at consolidating and strengthening their helps and reciprocal activities. Also, many associations have deregulated their systems in accordance with present and future needs of their members. In contrast, some deregulations initiations can be seen with future needs and expectations, according to respondents' views.

The geographical distribution of networks ties (e.g. Johnston and Pattie, 2012, P.301) is also identified as one of main components behind the variation in reciprocal support provision particularly in flood disaster context. Importantly victims who are located farthest away from reciprocal networks or in the locations where difficult to reach for supporters have mainly been influenced by disasters. Especially, some flood affected villagers are situated in very remote areas and undergo with high depth of flood inundation. They generally selected to stay at nearby shelters where located in highland areas (there are many in both rural DSDs' landscapes) and those areas also have been encircled by rushing floodwaters. In these scenarios, boat riders (supporters) have faced a plenty of difficulties and impediments as the access paths are being blocked mainly with the trees and bushes with the inundation depth of 15-20 feet. This situation has been worsened particularly in the night as the electricity supply has disconnected due to the floodwaters. Therefore, the notion of spatiality has been diversified the amount of reciprocal supports at disaster events in all the means.

In the modern village society, many people going out from the village for their occupations (majority of them are working in private sector) in the week days and village level creche facilities available in order to care kids of employed actors. In contrast, kind of daycare creche facilities in which provided by unemployed network actors are identified as foremost advantage of modern networks. Not only

for flooding events, but also socio-economic networks can have many genres in terms of their objectives and missions. For instance, helping victims, helping for weddings and funerals, collaborating with agricultural activities, aid programs etc. The underline message of village socio-economic s networks is that, the egalitarian nature transcends the rest of all impediments. In contrast, the study revealed that the egalitarian socio-economic networks have transcended the existing barriers. This dialectic approach reveals that the exact behaviors of egalitarian networks. Therefore, the egalitarianism may be the paradigmatic feature of village socio-economic networks. This is because, I have been planned to stake much of my scholarship on socio-economic networks and their behavioral aspects particularly on flood inundation events.

In particular, urban informal HHs are exemplified that they don't have rich and dense social ties and collaboration that is may be due to their socio ecological circumstances as explained earlier compare to the rural GNDs. The head of the GNO (Ms. Sriyakanthie) of Colombo DSD also urged that during mass flooding in 2016, all the GNOs and DSD officials with disaster management office have been managed the evacuation plans and supply programs for flood victims. Despite, the settlers have not been engaged with collaborative works and even they didn't support for preparing foods such as cooking for victims. Sometimes flood victims of urban areas have to secure their belongings during flooding as some of them have been stolen by underworld gangsters in order to making money for drug consumptions like heroin.

Despite some of HHs urged that GNO's party politics activities often are being baffling village lives. This is because, villagers are very skeptical of political motives. Furthermore, they highlighted that flood victims were completely baffled by lopsided political aids programs. Also, some blamed that GNOs and politicians have been abysmally ignored the villagers basic needs as well. Some of HHs level discontents are observed over the lopsided aiding and selecting grant recipients by GNOs who directly linked with or agents of party politics and also some of subtle differences can be seen among GNOs. In other words, one of the central inquiries in which posed by villagers is that lopsided way of selecting households for aids programs. However, supportive and aids programs have fortunately been attenuated the difficulties and hardships in plenty particularly on income levels. My personal observation on some of these claims is that many of HHs who are belonged to the opposite political parties are made negative inferences. Very often, Buddhist temples, government schools, community centers are arranged as flood recovery centers and that is regarding with their nearest location to inundated villagers. Generally community centers are too small in size compare to the other centers in which used to cram in more victim families and they often blamed to GNOs. Some

respondents point that the responsibility of local authorities e.g. GNOs is at the rock bottom on arranging. Nevertheless, there have been possible some of ill-wills and doctrinaire practices on aid programs. Furthermore, some of emerging anomalies of socio-economic networks such as trying to inject personal ideologies and trying to control networks in accordance with their personal agendas can be seen. This is very obvious and general in any societal system. Particularly, some HHs in urban informal settlers have provided with incorrect and misleading information and hard to disentangle the real information form the rest of lies. Many of general information were clarified after the discussions of GNOs.

Generally, in the flooding events, they are expecting aids from outside whether they have enough foods and resources or not and their imagination on aids can clearly identify by their greater celebration with fanfare when they receive those. However, the costs in which the government has still been bearing in order to maintain the social welfare legacies are incalculable (Karunarathne and Andriesse, 2018). All in all, Village socio-economic networks have become 'mesmerizing mantra' in village lives in which helped often 'depressed classes' of rural livelihood. According to my personal view, villagers' sentiments should have to come to the fore, when consider the policy establishments on village level issues such as flood disaster consequences. Also, dramatic trends can be seen in sentiment village level against party politics activities in village socio-economic networks.

Socio-economic network measures and network graphs analysis

According to the results revealed, network measures and graphs analyses have exemplified significant differences especially between rural and urban contexts and their reciprocal supports network characteristics. Especially, Network actors' attributes are determined by their reciprocal supportive activities. Therefore, actor attributes are shaped the structure of networks. In other words, reciprocal supports are influenced in shaping networks structures. Therefore, previously analyzed network measures and related graphs have complementary links with reciprocal supports ties and resource exchanges. However this argument has a lean controversy with the networks sizes in the theoretic notion. Generally, larger networks (e.g. with many nodes or actors) possible to have many exchanges and the magnitudes of their measures are quite low as all the nodes are not linked with each other (e.g. Wasserman and Faust, 1994; Scott and Carrington, 2011) while small size networks possible to have quite larger degree (e.g. Scott, 2010) which means degree density could come from zero side towards one (0-1, but impossible to become equal to 1, or complete graph). On this background, some of GNDs in urban context illustrated with higher degree density figures, for examples,

Mahawatta, 0.125 at during phase and 0.10/ after phase (with 9 actors including 6 HHs); Mattakkuliya, 0.111 at during phase and 0.091 / after phase (with 11 actors including 8 HHs, table 4.6), compare to rural dense support networks, for examples, Raddella , 0.009 at during phase (with 135 actors including 45 HHs); Haldola, 0.01/during (with 97 actors including 42 HHs) and 0.012/after (with 138 actors including 42 HHs) (table 4.5).

Moreover, Bodin and Crona noted that when higher the network density, possibilities for collective actions will be increased. They point also that *"networks including actors with both very high and very low centrality have a high overall network centrality"* (Bodin & Crona, 2009). Therefore, more centralized networks have been involved with more reciprocal activities. The analysis of the results is revealed that the network centrality has such irregular patterns as discussed GNDs vise earlier.

Practically, network behaviors at flooding situation are almost differed from their formal life networks. Formal life ties are much denser than ties in which formed in flooding events in rural areas. It is very general that the disrupting of formal ties during flood inundation. Some of very recent disaster networks studies have found that the main network measures are increased from the first stage to the next disaster stage. For example, according to Lu (2017, P.151), the average in-degree of information sharing has increased from before to emergency response stage related to the Wenchuan earthquake. Similarly, Misra and colleagues found that three network measures have increased from pre-disaster to phase I and then gradually decreased (Misra, *et al,.* 2017). Regarding the flooding scenarios, the networks formation is solely depend on the abilities to access. According to Varda (2017, P.52), the pre-disaster networks density (e.g. helping each other for preparation) is decreased at during disasters and then became normal after the disaster. Regarding this study, key networks measures of all the GNDs (15) of rural context, have decreased from before to during phases and then increased at after phase (table 4.4, 4.5). Despite, in all the urban GNDs, the key measures are increased from before phase to during phase and then decreased at after phase. This may because regarding the urban HHs they have had much opportunity to link with many actors at during phase as the majority of them have stayed at community centers. In the urban context, I personally experienced relatively dissimilar structural ties of flood disaster networks particularly in terms of reciprocal supports. In some cases (but not all urban GNDs), on interviewees' ends, they noted that they didn't have much collaborations with GNOs in the flooding events and they named three members of parliaments (MPs) who supported mainly with foods and other basic needs, sheltering (facilitated with temporary evacuation centers), during and after flood inundation. And also, all the sampled HHs in Colombo area was

belonged to the informal settlements for examples, shanties and slums. The number of ties and the length of relationships of their ties are very short compare to the regional areas. I believe that these narratives have highly influenced to the figures of three phases of their networks. A potential instance for this nature is that many HHs found in which isolated in their flood disaster networks (isolated nodes). Nevertheless, ties of volunteers (e.g. MPs) have shaped the networks structures and densities instead of GNOs' role. At the GNOs' end, the head GNO of Colombo DSD noted that they played a crucial role in providing and managing the needs of victims of 2016 mass flooding event during 24 hours. I was often curious about some of information provided by urban respondents on flooding events.

Table 4.7 depicts that the pared-samples *t* test results of the evolution of main network measures over time. According to the table 4.7, Kuruwita network measures indicated that the significant changes related to all the phases. For examples, related to the before/during, before/after and during/after phases, the degree density has significantly changed over time (e.g. *p* 0.008, *p* 0.003, and *p* 0.02, respectively).

Similarly, closeness and betweenness centralities of Kuruwita GNDs also have significantly evolved and changed over time (Table 4.7). For instances, related to the before/during, before/after and during/after phases, the *p values* of closeness and betweenness centralities are indicated as *p* 0.008, *p* 0.004, *p* 0.001 and *p* 0.001, *p* 0.004, *p* 0.001, respectively. Elapatha socio-economic networks' measures are also exemplified significant changes over time. For examples, significant of degree density over before/during, before/after and during/after phases, depicted as *p* 0.003, *p* 0.004, *p* 0.003 respectively. And also, related to closeness and betweenness centralities, the *p values* are indicated as *p* 0.01, *p* 0.058, *p* 0.002 and *p* 0.008, *p* 0.110, *p* 0.000 respectively. In particular, according to the statistical evidences, the changes of closeness and betweenness centralities from before to after phases related to Elapatha GNDs are not significant (e.g. *p>0.05).* Nevertheless, socio-economic network measures of all the GNDs have evolved over time numerically (e.g. table 4.4). Regarding the changes of urban network measures, the degree density from before to during phases (e.g. *p* 0.005); closeness centrality from before to during and from during to after phases (e.g. *p* 0.013 and *p* 0.013 respectively) have statistically been significant. The rest of pares have not been statistically significant. However, some of numerical changes of figures are seen (e.g. table 4.7).

Table4.7: Statistical significant of the changes of main network measures over time (the results of pared-samples t – test)

DSDs/ Sectors/ Overall	Degree density			Closeness Centrality			Betweenness Centrality		
	Before/ during	Before/ after	During/ after	Before/ during	Before/ after	During/ after	Before/ during	Before/ after	During/ after
Kuruwita	Mean/*b.* 0.039 Mean/ *d.* 0.033 SD 0.004104 *P* 0.008*	Mean/*b.* 0.039 Mean/ *a.* 0.045 SD 0.004138 *P* 0.003*	Mean/*d.* 0.033 Mean/ *a.* 0.045 SD 0.00684 *P* 0.02*	Mean/ *b.* 21.74 Mean/ *d.* 18.39 SD 2.554 *P* 0.008*	Mean/ *b.* 21.74 Mean/ *a.* 32.08 SD 6.9689 *P* 0.004*	Mean/ *d.* 18.39 Mean/ *a.* 32.08 SD 6.463 *P* 0.001*	Mean/ *b.* 5.34 Mean/ *d.* 4.0 SD 0.6948 *P* 0.001*	Mean/ *b.* 5.34 Mean/ *a.* 9.11 SD 2.57 *P* 0.004*	Mean/ *d.* 4.0 Mean/ *a.* 9.11 SD 2.8286 *P* 0.001*
Elapatha	Mean/ *b.* 0.018 Mean/ *d.* 0.016 SD 0.000951 *P* 0.003*	Mean/ *b.* 0.018 Mean/ *a.* 0.021 SD 0.001512 *P* 0.004*	Mean/ *d.* 0.016 Mean/ *a.* 0.021 SD 0.00236 *P* 0.003*	Mean/ *b.* 16.54 Mean/ *d.* 14.13 SD 1.716 *P* 0.01*	Mean/ *b.* 16.54 Mean/ *a.* 19.0 SD 2.776 *P* 0.058	Mean/ *d.* 14.13 Mean/ *a.* 19.0 SD 2.5493 *P* 0.002*	Mean/ *b.* 2.71 Mean/ *d.* 2.04 SD 0.4536 *P* 0.008*	Mean/ *b.* 2.71 Mean/ *a.* 3.21 SD 0.7047 *P* 0.110	Mean/ *d.* 2.04 Mean/ *a.* 3.21 SD 0.3352 *P* 0.000*
Colombo	Mean/ *b.* 0.046 Mean/ *d.* 0.081 SD 0.017754 *P* 0.005*	Mean/ *b.* 0.046 Mean/ *a.* 0.062 SD 0.016018 *P* 0.056	Mean/ *d.* 0.081 Mean/ *a.* 0.062 SD 0.019813 *P* 0.067	Mean/ *b.* 22.47 Mean/ *d.* 33.09 SD 6.90064 *P* 0.013*	Mean/ *b.* 22.47 Mean/ *a.* 24.91 SD 11.10532 *P* 0.614	Mean/ *d.* 33.09 Mean/ *a.* 24.91 SD 5.3363 *P* 0.013*	Mean/ *b.* 2.55 Mean/ *d.* 11.87 SD 9.22438 *P* 0.056	Mean/ *b.* 2.55 Mean/ *a.* 5.23 SD 3.84481 *P* 0.148	Mean/ *d.* 11.87 Mean/ *a.* 5.23 SD 10.76577 *P* 0.191

Notes: b-before, d-during, a-after; * = $p < 0.05$; confidence level 95%, n = 405.

All in all, the changes of network measures over time have statistically been significant in rural GNDs compare to the urban GNDs' network measures. However, many of changes are observed especially in GNDs' levels as discussed in details earlier. Especially, regarding the temporal dimension of networks, none of established theory can be found for studying dynamic nature of networks and the only way is to graph network measures against time (Varda, 2017, P.51).

In the rural context, reciprocal ties are not only appeared at adverse situations like flooding events, but also they have been seen in the normal daily life and much densely at festival seasons. For example, in the *Sinhala Aluth Awurudu* festival season, people are being inviting village members (relatives, neighbors, family members and friends) for lunch or dinner and they reciprocated the same. Generally, villagers (especially, relatives, neighbors, family members and friends) are being reciprocating foods, goods, and services between each other, and that is not confine to disaster situations. Thus, village-level socio-economic networks have been making more consolidated forms as several networks have intertwined with each other in terms of improving reciprocal practices in difficult situations. This study revealed that the experimental evidences of having instrumental reciprocity in the village socio-economic networks and proved the egalitarian nature of their resource networks. Egalitarian networks also help to attenuate the households' income disparities. These facts present comprehensive exposition to the notion of egalitarianism. Actors of socio-economic networks have been spent 'an immense of time' on egalitarian works in the flooding events as explained in detail earlier.

The evolution of networks measures over time may depend upon the case scenarios. This may because Misra and colleagues' study revealed that main social network measures have reduced after the Aila cyclone disaster in India (Misra, *et al.,* 2017), but they didn't investigate the regional diversities of support networks. According to Lu (2017), the level of communication activity of civil society actors has dramatically shifted ("from before the earthquake to the emergency response stage") by increasing the average in-degree for information exchange from 2.7 to 9.8. In the typical notion, the density of social networks could be come to natural level (from lower level to higher level) after disaster events (e.g. Varda, 2017). This study reveals that the similar narratives after flood inundation phase in particular, related to all the rural geographical settings.

More isolated HHs are observed (related to all the phases) in urban GNDs compared to the rural GNDs as discussed in previous section in details. This is because, yet there has been a range of collaborations and reciprocal exchanges in rural areas rather than urban informal settlements. And also, clusters or subgroups formations are investigated at before and during phases particularly in the rural networks (as depicted in 4.2 - 4.5, 4.7 - 4.10 figures) and also at all the phases in

urban networks (illustrated in figures 4.12 - 4.14). Moreover, more distributed networks observed at after phases almost all the GNDs compared to more centralized network topologies at during phase.

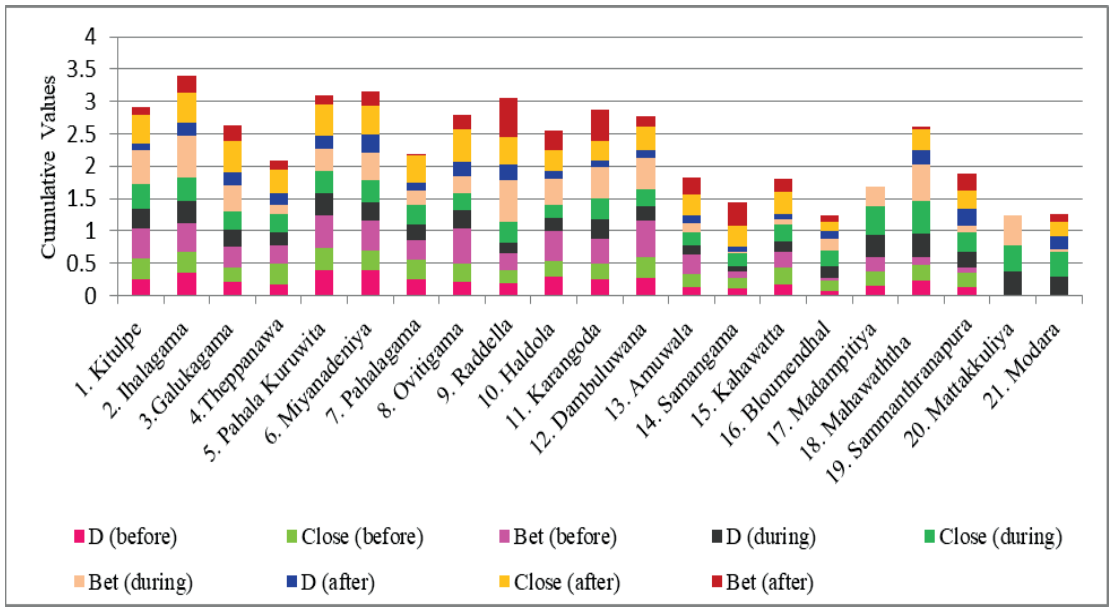

Figure 4.20: GNO's Role and Positions in the socio-economic network evolutions
Note: D = degree density; Close = closeness; Bet = betweenness (data: Appendix 1,Table A-5).

The changes of network measures are solely depending on the behaviors of network actors (e.g. reciprocal support mobilizations etc.). For an instance, GNOs identified as the key actors in the flooding events in almost all the GNDs. Practically GNOs, as the local level admin officials, they have to play a pivotal role in managing and facilitating the adverse situations, in particular, regarding disaster situations in their GNDs. In contrast, generally, a range of ties has been forming connecting GNOs in the flood inundation events in terms of efficiently organizing events, provision of information, managing reciprocal supports including sheltering, resources and material sharing and mobilizations, interlacing with victims and community networks in coping strategies, and so on. These activities help to make the structural position of key actors like GNOs in their community socio-economic networks. In other words, GNOs' role and the position in the flooding events have effectively been shaped the structural evolutionary patterns of socio-economic networks. On the other hand, it could be crucial as, *"...relatively few structural analyses of networks in disaster studies exit. Examining network structures in disaster contexts could potentially reveal important relational dynamics..."* (see, Faas and Jones, 2017, P. 17). The temporal evolutions of network graphs in which

related to three flood inundation phases of almost all the local admin units show the important relational dynamics of GNOs and the rest of actors.

Figure 4.20 illustrates that GNO's role and positions in the socio-economic network evolutions over time and table A-5 (appendix 1) shows the spatiotemporal evolutionary dynamics of relevant network measures (e.g. degree density, closeness and betweenness centralities) of GNOs. In particular, GNO's degree density indicates simply the number of ties or links and of the ways in which how affected people have interlaced in terms of trust, cohesiveness, and collaboration with GNOs. And also, it implies the level of reciprocal support and resource mobilizations. Similarly, closeness indicates how GNOs close and proximity to other actors and more crucial in disseminating of information and related services in disaster situations. More importantly, the betweenness also implies that the role of GNOs as gatekeepers (or brokers) of flood inundation support networks, playing seminal role in managing adverse situations in respective GNDs. The average network measures related to GNOs are quite larger compared to GNDs' average values (see, table A-5, appendix 1). In particular, average closeness figures have increased from before to during, and then at after phases in both Kuruwita and Elapatha DSDs while it has increased at during phase compared to before and after phases in Colombo DSD. Similar narratives observed related to closeness and betweenness centralities as well in Colombo DSD. The degree densities at before and during phases have increased compared to the rest of phases of Elapatha and Kuruwita DSDs respectively. The degree density at after phases of all the GNDs have decreased compared to the rest of phases. The evolutions of key network measures of GNOs show quite irregular patterns at GND level in all areas (see, table A-5, appendix 1). Figure 4.20 illustrates the crucial notions on the role and position of GNOs (cumulatively by all the measures) at their respective GNDs at different phases. For instances, Ihalagama and Theppanawa in Kuruwita DSD, Raddella and Samangama in Elapatha DSD, Madampitiya and Bluomendhal in Colombo indicate the highest and lowest positions of GNOs respectively. In particular, field observations proved that GNOs of Ovitigama and Raddella GNDs have effectively been played their managerial and coordinating roles in the flood inundation events, also facilitating to other GNOs as well. The head of the GNO of Colombo DSD also explained her extraordinary coordinating roles in facilitating flood victims.

At the affected people's end, linking with local authorities can be identified as the strengthening of "linking social capital" (see, figure 4.35). Linking social capital is a key part of the structural social capital. Therefore, "an actor that is central in a network of social interactions likely has greater potential to formally collaborate with other actors and hence has greater structural social capital"

(Nawinna and Venable, 2019). These linking social capital, in particular, affected people are often engaged with GNOs and exemplified more dense ties with them. This can visually be seen in the typologies of network graphs. For example, the GNO has played a key role at all the phases of Ovitigama, Ihalagama, Galukagama, Theppanawa etc. GNDs in Kuruwita DSD (e.g. Figures 4.2-4.5). At the after phase of GNDs like, Pahalagama and Kithulpe, the proportional size of GNOs is fairly small. In contrast, their ties have reduced at after phase compared to before and during flood inundation phases. Regarding Elapatha DSD, at all the inundation phases of Raddella, Haldola, Karangoda, Dambuluwana, and Amuwala GNDs; at before and during phases in Kahawatta GND; at before phase in Samangama GND, GNOs observed as key network actors (Figures 4.7-4.10). In urban GNDs, for example, at before phase of Madampitiya and Mahawatta GNDs; at after phase of Bleomendhal and Sammanthranapura GNDs (Figures 4.12-4.14), GNOs seen as key network actors.

The notions of social role or in other words structural role of such social network actors are determined by their ties with other actors. In accordance with the network science, if some of actors (e.g. two individuals) have the similar ties or structural similarities and patterns (e.g. similar structural roles / positions) with other actors and also, similarly receiving ties from same other actors, they are structurally equivalence (Wasserman and Faust, 1994, P. 348; Borgatti, *et al.,* 2013, P. 206). Structural equivalence is important to understand actors' similarities in attitudes, behaviors, similar social environment, and homogeneity (Borgatti, *et al.,* 2013, P. 207). In regarding to this study, it may implies that the evolution of structural similarities of actors (helpers and households) in the sense of temporal dimensions. In other words, how the structural equivalence ties have shaped or evolved over time (before, during, and after phases). One of the most famous ways of measuring actors' structural equivalence ties is that the calculation of correlation matrixes of ties (e.g. generally consider the symmetric matrixes with similar number of rows and columns) and perfect structural equivalence represents by a correlation coefficient of +1, while 0 means no structural equivalence (Borgatti, *et al.,* 2013, P. 212; Scott and Carrington, 2012, P. 429). Since this study has considered 21 local admin units, it is such a cumbersome practice to show 63 correlation matrixes portraying their structural equivalences. Therefore, study illustrates the number of perfect and considerably structurally equivalence pairs of actors related to each admin units with their temporal aspects (see, table 4.8). The results revealed that Elapatha sampled GNDs, for examples, Raddella, Haldola, Karangoda, Dambuluwana, and Amuwala exemplified with large number of structurally equivalence pairs compared to the rest of admin units.

Table 4.8: Structural Equivalence among actors / number of pairs, observed with perfect and considerable Structural Equivalence

GNDs/	Before		During		After	
	Perfect SE (r = +1)	Considerable SE (r =1-0.5)	Perfect SE (r = +1)	Considerable SE (r =1-0.5)	Perfect SE (r = +1)	Considerable SE (r = 1-0.5)
Kitulpe	6	3	2	7	0	2
Ihalagama	10	5	5	2	0	3
Galukagama	10	4	18	11	0	7
Theppanawa	0	1	5	3	0	0
Pahala Kuruwita	7	4	6	8	0	4
Miyanadeniya	19	6	4	18	0	17
Pahalagama	4	1	3	1	0	0
Ovitigama	4	5	12	9	0	5
Raddella	29	17	4	16	2	9
Haldola	20	11	11	20	6	7
Karangoda	15	23	12	46	3	8
Dambuluwana	10	11	18	37	1	4
Amuwala	9	10	26	31	2	9
Samangama	2	0	5	1	0	2
Kahawatta	1	0	4	0	0	1
Bluomendal	17	2	23	3	16	9
Madampitiya	9	3	17	2	9	7
Mahawaththa	3	1	5	2	4	2
Sammanthranapura	8	2	9	1	6	3
Mattakkuliya	4	2	4	1	5	2
Modara	6	0	8	0	2	1

Notes: Pearson correlation coefficients: +1 = perfect structural equivalence; 0 = No equivalence; SE = Structural Equivalence.

In particular, urban small size networks represent with higher number of structurally equivalence pairs (e.g. Bleomendhal, Madampitiya, Sammanthranapura etc.) compared to rural networks. In Kuruwita GNDs, Ihalagama, Galukagama, and Miyanadeniys etc. depicts with considerable number of structurally equivalence pairs. Especially, none of structurally equivalence pairs was found at the after phase of Kuruwita sample GNDs in accordance with their correlation

matrixes. Similarly, Samangama and Kahawatta GNDs of Elapatha DSD also observed with no structurally equivalence at after phase. And also, Kithulpe, Theppanawa, and Pahalagama GNDs in Kuruwita DSD; Samangama and Kahawatta GNDs in Elapatha DSD; Mahawatta, Mattakkuliya, and Modara GNDs in Colombo depicted with little number of structurally equivalence pairs. All in all, Elapatha GNDs observed with large number of perfect and considerable structurally equivalence pairs at before and during flood inundation phases compared to the after phase.

Particularly, the analysis of networks measures, their characteristics, and network graphs of this study has strong epistemological and theoretical background. For examples, according to Freeman (2004, P.3), there has been four features in which categorized based upon the modern social network analysis. Firstly, social network analysis is motivated by a structural intuition based on ties linking social actors, secondly, it is grounded in systematic empirical data, thirdly, it draws heavily on graphic imagery, and finally it relies on the use of mathematical and /or computational models. Similarly, the applications of these features can be found in the recent network analysis approaches on disaster response, recovery and adaptation (Jones & Faas, 2017). Thus, social network analysis mainly involved with the attributes of investigated networks. For example, the structural characteristics such as density relations, degree of centralization and cohesiveness (Bodin & Crona, 2009) and basic structural properties such as reciprocity, transitivity, and clustering (Lu, 2017, P.147) are identified as more important aspects. In contrast, the analyzing of social structures, their relational aspects, for example, the patterns of direct and indirect contacts of actors (e.g. Scott, 2010, P.38, P.123) are solely based on the network attributes. And also, the size and density of networks make overall sense for possible social structures in plenty (Hanneman & Riddle, 2012, P.342). Bodin and Crona (2009) revealed that the behavioral notion of actors has mainly been influenced by the structural patterns of relations (for instance topology) of social networks. And also, structural differences exemplified by density relations, degree distribution (cohesiveness and centralization), and subgroup interconnectivity in accordance with their findings. For Kapucu & Demiroz (2017, P.37), the key elements of network structure may comprised with reciprocity, mutuality, and egalitarianism. These features of collaboration are significantly influenced in terms of disaster response and recovery. Egalitarian networks and reciprocal exchanges are cardinally important in the context of Sri Lanka flooding events and have been more common particularly in rural areas. Perkins, Subramanian, and Christakis's (2015) study revealed that the composition of networks, centrality (individual), and network structure have associated with health outcomes and behaviors. Stewart, Glanville, and Bennett's (2014), study

suggested that volunteer behavior has been significantly related with network density and diversity. On this background, this study theorized the rural-urban socio-economic network behaviors in flood inundation events by investigating their characteristics and measures based upon considerably a larger sample in which belonged to geographically variegated social settings as the first attempt in disaster network analyzing discourse in Sri Lankan context.

4.1.5. Organizational networks behaviors on rural-urban flooding events

Organizational practices in disaster situations can be identified as one of the key components in providing resources and facilities. In particular, organizational networks have been interlinked with ground level socio-economic networks at disaster events by fulfilling the vacuum of facilities provisions for the victims. In this context, organizations and their networks have been becoming more important on the context of disaster management and mitigation in terms of resilient and coping capacities at multiple levels (e.g. Stevenson and Conradson, 2017, P. 162; Htein, Lim, and Zaw, 2018). Regarding this study, I also investigated the organizational network behaviors on the flood inundation events. The information of organizational networks is mainly gathered through the discussions made with GNOs and from focus groups interviews. HHs respondents also explained their experiences about organizational supports. And also, I personally made telephone call conversations with some of identified organizations. In accordance with the facts that observed, the organizations have mainly functioned between during and after flood inundation phases. Therefore, mainly three organizational networks are identified in which related to Kuruwita, Elapatha, and Colombo DSDs.

Especially, many of supportive organizations have contacted mainly with relevant DSD offices and GNOs of inundated GNDs in order to provision of supports for the flood victims. Figure 4.21 illustrates the organizational support networks of Kuruwita flooding event. Especially the majority of organizations are belonged to the government sector, for examples, DSDs, GNOs, forces, police, CSF, MOH, and DMC etc. Kuruwita DSD have provided for inundated HHs with processed foods and basics needs in cooperating with GNOs and public donations. More importantly, some of DSDs (e.g Matale, Bandarawela, Gampaha, Mahara Kadawatha etc.) which are located in faraway admin districts have made different supports such as dried foods, water, basic needs, cloths, and school items and stationary for flood victim HHs in collaborated with Kuruwita DSD office and GNOs.

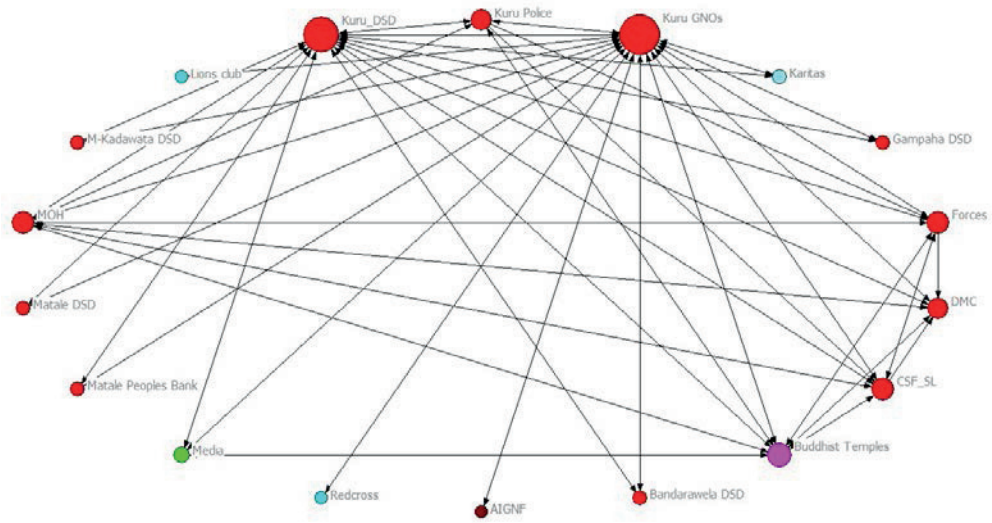

Figure 4.21: Organizational network of Kuruwita flooding event. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for government organizations, light Blue for NGOs, Pink for Buddhist temples, Green for media organizations, Brown for others.*

According to GNOs, Buddhist temples have played a pivotal role in providing facilities and their premises as shelters and also distributing foods for affected people. And also, civil security forces (CSF) members (three to five members) have stayed in inundated GNDs and facilitated with evacuation supports and cleaning HHs as well as public places, wells etc. Other forces members and police members also have engaged with support activities in plenty. NGOs and media organizations also have supported in many ways by providing foods, water, and basic needs etc. The degree density, average degree and degree centrality are indicated with 0.281, 4.778, and 80.9% respectively related to organization network of Kuruwita DSD. It is obvious that those figures are quite high compare to the HHs socio-economic networks measures.

Figure 4.22 shows that the organizational network of Elapatha DSD. Elapatha organizational network also exemplified with higher number of government organizational collaborations compare to the rest of actors. Similarly, all the supportive organizations have collaborated with the Elapatha DSD office and GNOs in order to provide their supports for victims. Their supports ties are very important for villagers as some of Elapatha GNDs are experienced with 15 to 20 feet inundation depths.

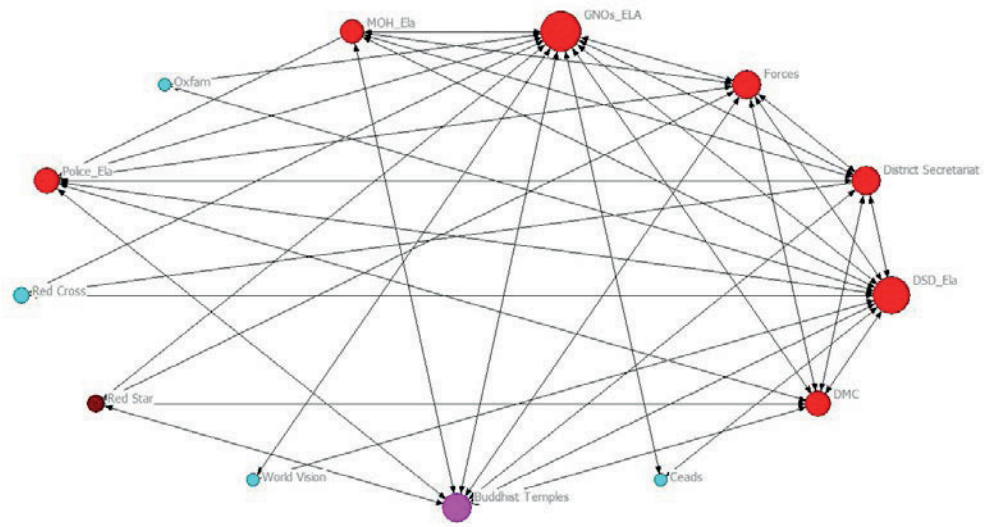

Figure 4.22: Organizational network of Elapatha flooding event. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for government organizations, light Blue for NGOs, Pink for Buddhist temples, Brown for others.*

Especially, Rathnapura district secretariat and Elapatha DSD have mobilized and coordinated organizational supports in terms of providing cooked foods, drinking water, and other basic needs for displaced and inundated villagers in plenty of ways. DMC also has played crucial role in providing evacuation supports such as provision of fiber boats for all the supportive activities in collaboration with the DSD and GNOs. Forces members and NGOs (e.g. Oxfam and Ceads) have contributed with many ways in provision of material and nonfinancial supports on order to revivify the adversely affected village livelihoods. Similarly, many Buddhist temples have occupied in providing a range supports for victims and HHs respondents also highlighted their supports were very instrumental in forestalling adverse impacts and consequences of flood disasters. In related to the abovementioned ties, the degree density, average degree, and degree centrality are depicted as 0.494, 5.923, and 59.8% respectively.

Figure 4.23 shows that the organizational support network of Colombo flooding events. Colombo DSD, DMC and their GNOs have played major role by collaborating with other supporting organizations. The head of GNO of Colombo DSD pointed out that they worked hardly in flooding events (especially in 2016 mass flooding event) in order to provide foods and basic needs for flood victims. She further explained that inundation had been occurred maximum two to three days in Colombo Areas (but not in all the areas).

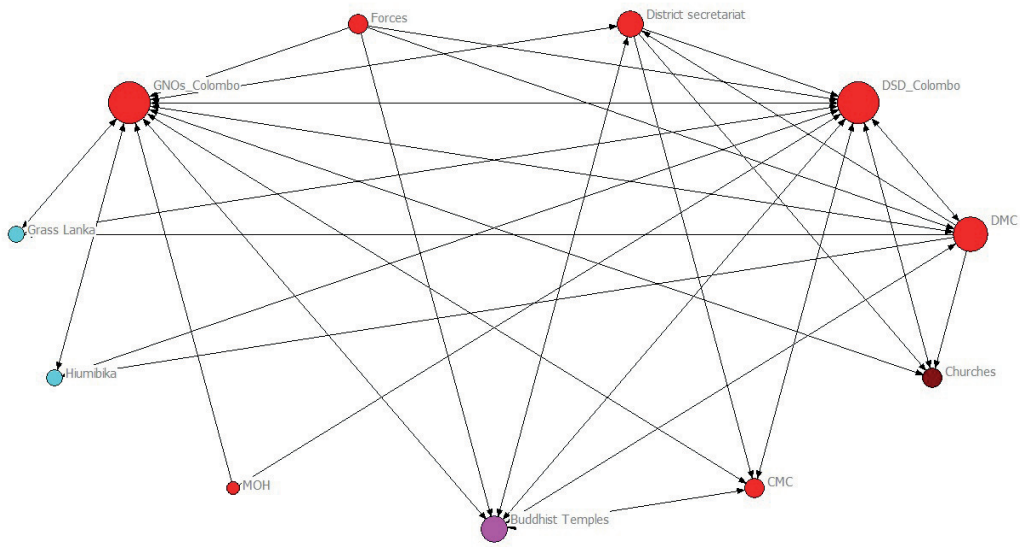

Figure 4.23: Organizational network of Colombo flooding event. *Notes: The size of each node represents their degree density (proportional). Colors of nodes: Red for government organizations, light Blue for NGOs, Pink for Buddhist temples, Brown for others.*

Buddhist temples and churches have facilitated with necessities including sheltering during flooding events. The chief GNO further noted that *Hiumibika* and and *Grass Lanka* NGOs engaged with them and provided basics needs (even sleeping mats, mosquito nets, baby items etc.) for families who affected from flood inundations. Regarding this network background, the degree density, average degree, and degree centrality are indicated as 0.427, 4.273, 70.0% respectively. At the HHs respondents' end, the majority of them urged that they didn't receive much supports form officials as well as from others and only received foods time to times at during flooding events. In accordance with my personal view and experiences their blames are impossible to account and consider as exact facts. Because of very few of respondents are confirmed that they received many supports from explained networks.

All in all, regarding the rural sector, Kuruwita DSD has received supports from many organizations and Elapatha DSD also has experienced many supports compare to Colombo DSD. This is because, on the one hand, the rural GNDs have been experienced mass inundation depth (in some cases, with more than two weeks inundation) and damages compare to urban scenarios. On the other hand, many poorest of the poor HHs are possible to be found in rural inundated areas and publics are being thinking that the foremost considerations must go to the those peoples, that is almost correct. Nevertheless, when considering the economic

hardships (but not the flooding wounds), many poorest HHs can be found in informal settlement areas. Therefore, socio-economic networks have been the instrumental metaphor as well as significant remedy for healing the wounds.

In accordance with the existing body of literature, for instance, Doerfel, Chewning, and Lai's (2013) study revealed that the organizational resilience on pre-disaster ties and their relationships have played an important role in post-disaster reconstruction and disaster recovery practices related to Hurricane Katrina. Doerfel and Haseki (2015), also pointed out that the organizational media were more influential through their organizational networks for disaster management and rebuilding. Following the 2010/11 Canterbury earthquake, the victims have received a range of supports from the organizational networks and the assistance and services identified as the main common support category (e.g. Stevenson and Conradson, 2017, P. 167). In related to the 2015 and 2016 Myanmar floods, the military, government organizations, and their networks have been pivotal actors in flood disaster support and management (e.g. Htein, Limand Zaw, 2018). Therefore, similar narratives are found in this study regarding the organizational network behaviors and their supports in the flooding events, mostly in rural and also in urban contexts. One foremost important thing behind the organizational supports is they may provide some helps (e.g. health facilities and free of charge clinics by MOHs; water bottles, school items, cloths, financial and material supports, cleaning HHs and public places etc.) in which impossible to expect much from villagers' end. Therefore, villagers (e.g. Kuruwita GNDs predominantly and also Elapatha inundated GNDs) have received a range of reciprocal supports from organizational networks separately from the rest of socio-economic reciprocal networks which widely explained in previous sections. Despite some of GNDs (e.g. Pahalagama, Ovitigama, Miyanadeniya in Kuruwita DSD and Kahawatta, Dambuluwana and Raddella in Elapatha DSD) which are located very far away from main roads have lately received some of resources and helps mobilized.

This chapter examined the prowess and the ways in which reciprocal supports and resources shared and mobilized through a range of socio-economic networks in terms of preparing, recovering, and revivifying flood affected livelihoods of variegated rural and urban geographical settings. It also investigated that the spatio-temporal evolutionary dynamics of socio-economic networks and their intertwining nature with reciprocal support legacies in the flooding events. Especially, rural areas exemplified with very strong and dense reciprocal supports and related socio-economic networks compared to the urban settings. This chapter also revealed that the key network measures have evolved over time with different magnitudes in related to rural and urban areas.

Chapter 5. Social capital legacies for flood disaster preparedness and recovery

This chapter exemplifies the behavior of social capital legacies in response to flooding events and their daily lives. The notions of social capital and socio-economic networks can be identified as such complementary conceptions. In contrast, socio-economic network is the core metaphor of making social capital stronger and both conceptions have intertwined associations (e.g. Coleman, 1988; Putnam, 1993; Grootaert and van Bastelaer, 2002; Sabitini, 2009; Aldrich and Meyer, 2015; Islam and Walkerden, 2017; Norbutas and Corten, 2018; Shah, *et al.*, 2018 etc.). Regarding Sri Lankan societies, they have been maintaining very close relations and interactions with each other in terms of different cultural and social practices. Sri Lanka prominently exemplifies for rich cultural values (e.g. Daskon and Binns, 2010) and for rich indigenous knowledge (e.g. Ulluwishewa, 1993) particularly in the Asian region. Social capital has been interlaced with these values. Resource mobilizations and some of intangible values including information and emotions have often secured lives and have helped to revivify their livelihood without external support, even in the extreme natural disasters. In contrast, country's traditional socio-cultural values and practices have been influenced in terms of having better collaboration practices to conquer the hardships of flood disaster situations.

5.1. Implications of social capital legacies

Chapter 4 rigorously examined the "structural social capital behaviors" in the flooding events. This chapter examined how social capital (mainly "cognitive social capital behaviors") worked in the flood inundation events and the second section considered that how traditional social capital behaved in flooding events. More importantly, collaborative associations and groups of their daily lives are also concerned. A range of strong and complementary relationships are existing between structural and cognitive social capitals (e.g. Putnam, 1993). This chapter examined the characteristics of all the DSDs (Kuruwita, Elapatha, and Colombo) under relevant themes instead of considering separate sections for each DSD as occupied in previous chapter. This is because, there are many sub-sections are existed in the questionnaire related to actors' collaboration. Themes of social capital are solely based on the tool called Integrated Questionnaire for the Measurement of Social Capital (SC-IQ), which is introduced by the World Bank (Grootaert, *et al.,* 2004). This study only considered the most relevant sub categories of SC-IQ framework for this study.

5.1.1. Socio-economic associations and groups

Reciprocal socio-economic network supports are being mobilizing in the flood inundation events have very close associations with village level socio-economic associations and groups. The majority of sampled rural HHs have one or many memberships of these associations compared to the urban sampled HHs. In this context, one GND consists of many socio-economic associations and groups and they have been functioning aiming at people's wellbeing with different objectives. These associations have been strengthening both structural and cognitive social capital through village level bonding, bridging, and linking ties. Table 4.9 illustrates all the socio-economic associations reported in the HHs survey. These associations have their own specific objectives, for examples, Villagers have been provided labor (free of charge or voluntary) collaboratively for village level farming, irrigation canal maintaining and agriculture works (through farmer association called '*Aththan Kavi*') in a rotating manner. Similarly, *Shramadhana* is also a voluntary collective exercise which is used to rebuild and maintain village infrastructure facilities, including repairing common places like temples, *Prajasala* (village community center), schools, and even some of poorer houses. The village association called *Govi Samithiya* is also crucial in helping each other particularly for their agricultural and farming activities, making links and working with government sector in order to provide aids and fertilizer subsidies for village peasants. *Maranadhara Samithiya* and *Subasadaka Samithiya* associations have been providing with money donation (their assets made through villagers' contribution) for emergency assistants like village funerals, adverse events, and also for religious activities etc.

According to table 5.1, *Grama Sanwardana Samithiya* or village development association also has mainly been involving with the development of village infrastructure facilities. And also, special association like *Kantha Samithiya* have been provided aids and compensation for members HHs who undergone damages with sewing machines and refrigerators by flood inundations etc. Obviously, these activities have represented the collaborative nature of social capital which intertwines with their norms, values, beliefs and customs in a complementary way.
More importantly, the majority of aspects of village level livelihood have been covered by main themes and proxies of listed associations. On the other hand, this implies that the prowess of village level collaborative and reciprocal activities. In accordance with table 5.2, more than 95% of HHs are belonged to Kuruwita and Elapatha DSDs have memberships with one or many village associations and groups.

Table 5.1: Particulars and key activities of village associations

Name of Association	Theme(s) / mission(s)	Main activities
Dayaka Sabawa	Religious works	Development of temple, maintaining village harmony
Tharuna Bauddha Samithiya	Religious and charity works	Village activities, Charity works
Grama Sanwardana Samithiyta	Village developments and charity works	Maintaining and developing village infrastructures, charity works
Kulangana/ Mahila Samithiya	Women and religious activities	Women activities, religious activities
Kantha Samithiya	Women activities	Empowering village women, training, funding, making compensation for flood victims women
Bath Samithiya	Providing rice and foods	Providing foods for funerals, disaster events, village works
Govi Samithiya	Improving village agriculture activities	Providing soil, seeds (particularly paddy and others), labor, many kinds of help
Wedihiti Samithiya	Securing elders	Providing money for elders, providing healthcare facilities
Subasadaka Samithiya	Improving village livelihoods	Providing various helps for village activities, funding, provision of security for villagers, overall activities
Maranadara Samithiya / also, in Police, CTB etc.	Village funeral management	Funding for funerals, providing many types of help for funerals
Aththan Kayiya	Providing labors	Providing collaborative labors especially for agriculture activities *in a rotational manner*
Young association/ Tharuna Samithiya	Youth development	Youth development activities, developing sport activities etc.
Ekabadda Samithiya	Overall village development	Providing supports for village development
Sanasa Samithiya	Funding and development	Funding for employment development, lending monetary loans
Tea Samithiya	Improving village tea lands	Providing supports for small tea land holders
Sarvodhaya	Social and charity works	Supporting charity works and empowering villagers
Krida Samithiya	Sport development	Village Sport s development and supporting for other events

Source: Own HHs survey, 2018/2019

Table 5.2: Participation of HHs with associations and groups

GNDs	Number of Association reported	Mostly reported association	Average friends reported	HHs found with no memberships
Kitulpe	4	Maranadhara	42	0
Ihalagama	6	Maranadhara	34	1
Galukagama	8	Maranadhara	44	1
Theppanawa	3	Maranadhara	43	0
Pahala Kuruwita	5	Maranadhara	33	0
Miyanadeniya	5	Maranadhara	46	2
Pahalagama	4	Maranadhara	35	0
Ovitigama	7	Maranadhara	37	0
Raddella	6	Maranadhara	44	4
Haldola	5	Maranadhara	33	9
Karangoda	9	Dayaka Sabawa	41	7
Dambuluwana	6	Maranadhara	31	4
Amuwala	8	Maranadhara	36	3
Samangama	7	Kantha Samithiya	35	1
Kahawatta	6	Maranadhara	32	1
Bluomendal	2	Maranadhara	18	15
Madampitiya	1	Maranadhara	13	8
Mahawaththa	1	Maranadhara	11	3
Sammanthranapura	1	Maranadhara	14	5
Mattakkuliya	1	Maranadhara	9	2
Modara	1	Maranadhara	12	5
Rural Average	6		38	2
Urban Average	1		13	7

Source: Own HHs survey, 2018/2019

Compared to rural sector, Colombo sampled HHs exemplified with very low associations and despite more than 50% HHs reported with no any membership with associations or groups (e.g. Bluomendal shows 15 HHs with no any membership). In Elapatha DSD, Haldola and Karangoda GNDs, 9 and 7 HHs are indicated with no membership respectively. Many of those HHs were newly married families and they are willing to join with village associations in the future. Urban informal HHs respondents are urged that they don't have any appropriate association to join or others are not allowed to offer membership for them may be due to their social status or other reasons.

Regarding the number of associations, rural GNDs are reported with more than 6 (with Max. 9, Karangoda and Min. 3 Theppanawa) compared to the urban sector (average 1, Min.1, Max2). This may be disturbing situation for informal urban livelihood. This is very sorry tale compared to the rural livelihood. I personally postulated that their livelihood circumstances have been made by themselves. Their average group friends also depicts with low number (13), compared to the rural sector (38). Funeral aid association (*Maranadhara Samithiya*) is identified as the mostly reported association among surveyed HHs. Some small differences are seen among rural GNDs, but not big variations. Respondents have pointed that the majority of memberships in their associations are their friends. Uphoff and Wijayaratna (2000) have explained how associational activity help to stronger village level social capital and demonstrated as the combination of both structural and cognitive forms of social capital. In most of the cases, there is no confinement for other villagers to obtain their memberships. In particular, when villagers are faced adverse events such as flood inundation, the strengths of ties with these associations have been more instrumental.

Respondents confirmed that they have been received a range of supports and benefits from their associations including, monetary donations and supports, occupational training (in particular for women), aids, labor supports for special occasions and agricultural works, money loans and so on. Importantly, these narratives are seen in the rural geographical settings. In other words, lacks of livelihood opportunities are exemplified in urban informal settlements. According to the responses, very few personals are reported whose are leaders or very active positions in their associations. The majority of HHs memberships are not participating in decision making. But, they are actively participating for common village level activities that are conducting by relevant associations. Those are exampled for bonding and bridging social capitals in villages. And also, religious background, ethnicity, and linguistic backgrounds of almost all the rural reported associations are same (e.g. they are Buddhist and Sinhalese).Only two Tamil HHs (inundated) are found in Elapatha GNDs. They also have engaged with formal village associations. Generally no gender differences are found in their associations and groups except "women associations" (e.g. *Kantha Samithiya).* According to respondents, the occupational and educational backgrounds of memberships are variegated and diverse. Moreover, in the rural sector, respondents have much confidence about money borrowing from their relatives or from their networks for their sudden needs. For examples, they noted that they definitely (n=228, 69.7%) or probably (n=58, 17.7%) can be borrowed money. Few of them replied that is unsure (n=9, 2.8%) and probably not (n=32, 9.8%). Conversely, for examples urban respondents note that the possibility to borrow money from others is

definitely sure (n=9, 11.5%), probably sure (n=12, 15.4%), unsure (n=26, 33.3%), probably not (n=9, 11.5%), and definitely not sure (n= 22, 28.5%). This is because they don't have money for giving to others even in the situation where with many economic hardships. And also, they don't have much confidence and trust about each other, what they will do at the next moment. Regarding bonding and bridging social capital, many opportunities are on the table in rural areas compared to urban settings. Y. Minamoto has investigated and proved that the pervasive nature of social associations and their prowess in the societies in Sri Lanka (Minamoto, 2010).

5.1.2. Feeling trust and solidarity among respondents

The notions of trust and solidarity have also interlinked with the actors bonding and birding ties and social capital especially in needful situations. Trust, norms, and empowerment (e.g. World Bank, 2004) also are more inference to the cognitive notion rather than structural social capital and difficult to measure. But cognitive dimensions work well in socio-economic networks in particular, in the situations where unexpected encounters are occurred. More importantly, trust and solidarity are closely associated with formal and informal ties in terms of exchanging information and resources (see, Kapucu and Demiroz, 2017, P.34). In this study, I considered mainly respondents' feeling about trust on villagers, their willingness to help each other (daily life as well as flooding events), and also their trust on authorities. Tables A6 –A12 (in Appendix 2) show that respondents' views on trust and related norms related to all the rural and urban GNDs. On average, around 75% rural respondents have trust on their neighbors and villagers while around 13% and 12% are showed neutral and no trust feelings respectively.

In urban sector, around 42% respondents have trust on others while around 30% and 28% are indicated with neutral and they don't have trust on others respectively (appendix 2, table A-6). This is because they don't have much collaboration and solidarity with others in urban informal settlements. And also, very small changes can be seen among rural GNDs related to Elapatha and Kuruwita areas. Figure 5.1 presents the spatial (e.g. sectorial) difference of respondents' trust on villagers and neighborhood.

The survey results on willingness to help others when they need in day today life (table A-7, appendix 2) their trust on lending and borrowing money (table A-8, appendix 2) are also revealed similar narratives to trusting each other. In particular, regarding how well villagers are helping each other on flood inundation situations also indicated important results (table A-10, appendix 2). For examples, in rural areas around 80% are responded that they help others (often and most of the times)

in flooding events.

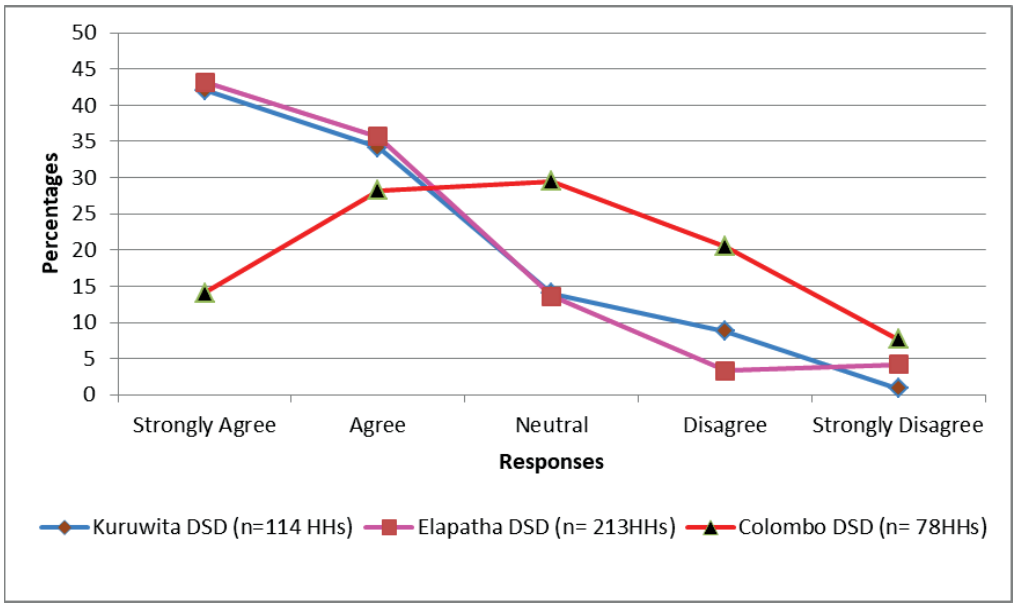

Figure 5.1: Trusting of villagers and neighborhood in day-today life

In urban areas, around 43% are helping when they experience flooding. On the other hand, results show that 8% and 2% in rural areas; 17% and 10% in urban areas are 'rarely helping' and 'never helping' in the flooding events, respectively.

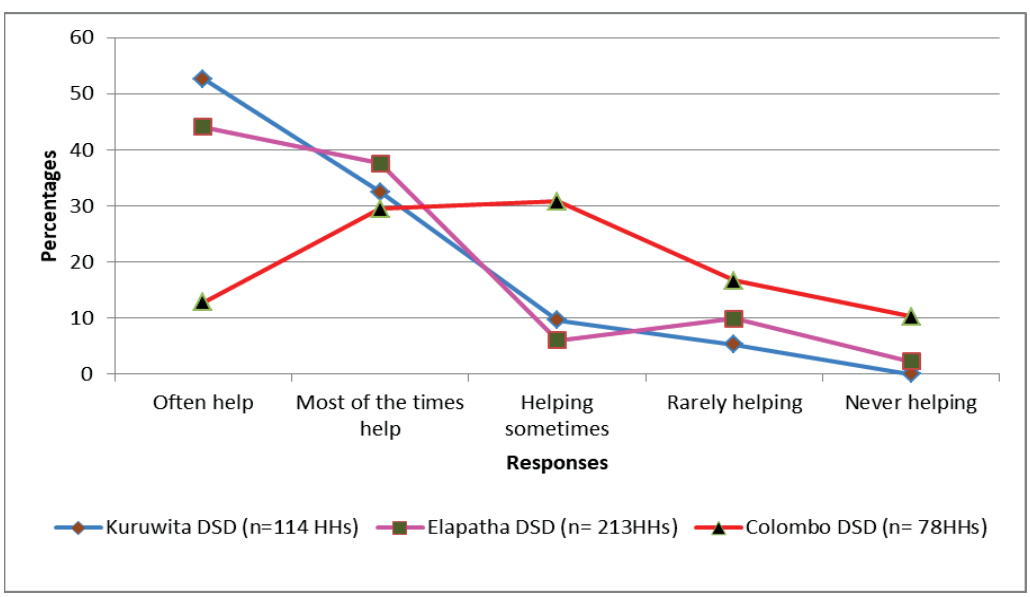

Figure5.2: Collaboration and helping each other in the flooding events

Figure 5.2 shows that the disparities among different DSDs. Other important

notion is that the majority of rural respondents urged that it is almost difficult to help other HHs during flooding because of all the inundating HHs are struggling to move out as soon as possible with their important belongings and they helps others when they confidence.

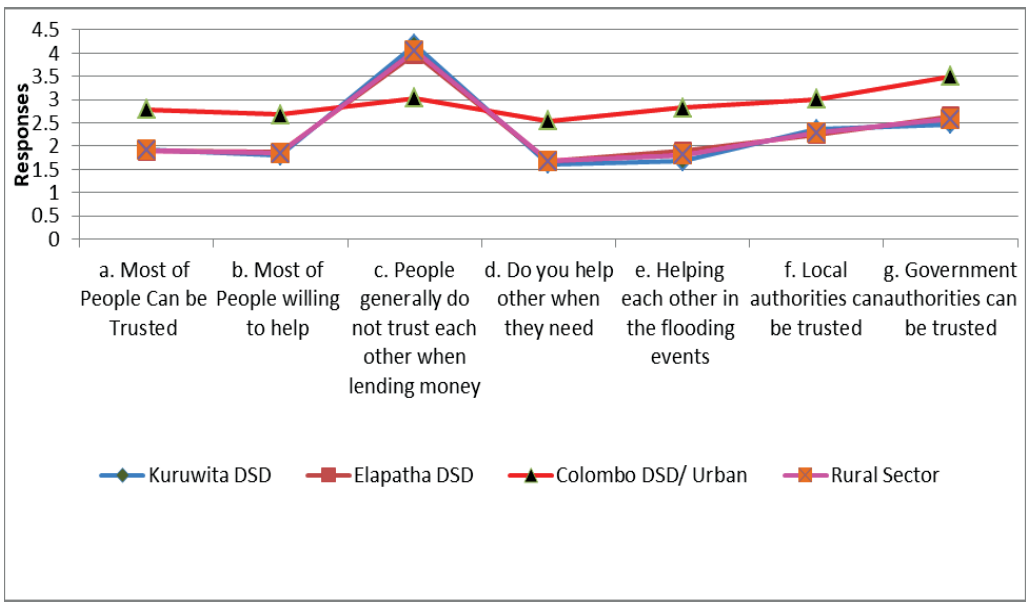

Figure 5.3: Average responses rating on all the trust notions; *notes:* ***a*** to ***d*** items considered 1=strongly agree, 2= agree, 3= neutral, 4= disagree, 5= strongly disagree; item ***e*** considered 1= often helping, 2= helping most of the times, 3= helping sometimes, 4= rarely helping, 5= never helping; ***f*** and ***g*** items considered 1= to a very great extent, 2= to a great extent, 3= Neither great nor small extent, 4= to small, 5= to a very small extent.

Figure 5.3 illustrates the comparison of overall ratings of responding on different aspects of trust and solidarity. Almost similar patterns can be seen in both rural DSDs compared to the urban DSD. And also, the averages of negative responses are quite high in Colombo DSD (negative responses may be mainly 4 and 5 including 3 at to some extent). The responses on local and government authorities are not much satisfactory (table A-11 and A-12, appendix 2 also show) especially in urban GNDs. Moreover, according to the revealed results, trusting people and their solidarity are very high in rural areas with some regional differences.

5.1.3. Collective actions and cooperation in daily life

Conceptions of collective actions and cooperation are very general in the flood inundation events and a range of reciprocal ties and exchanges can be seen as explained in detail in network section. Collective actions are very high in the communities with significant mobilization of social capital (e,g, Grootaert, *et al.,* 2004). Especially, after flooding events, (compare to before and during) a plethora of collective actions can be seen inundated areas including moving in belonging to HHs, cleaning HHs and public places and many other livelihood revivifying activities. Network graphs analysis also exemplified that the structural patterns of collective actions related to three flood inundation phases.

According to the results, 97.9% respondents (n= 320 HHs) in rural areas and 57.7% (n= 45 HHs) in urban areas are confirmed that in the past 12 months (when collecting data), they have worked with others in their villages in order to do something for the community. And also, 2.1% (n= 7 HHs) in rural areas and 42.3% (n= 33 HHs) in urban areas (table A-11, appendix 3) are urged that they didn't work with others. In urban informal areas, it is very general this kind of community relations. In rural areas, they have engaged with village activities (frequently reported) such as *Shramadhana* (very famous community works doing all together) in flooding events, charity works, various religious programs and activities, funerals, and many functions (including weddings) in past 12 months as voluntary activities in cooperated with their associations. Urban respondents also have pointed out that they participated with funeral functions, weddings, and other functions at their relatives or friends places.

Figure 5.4 shows that the likelihood to criticize people when they are not participation in community activities. In rural sector respondents are thinking that it is their responsibility to engage with community activities especially in the needful situations like flooding events. Rural villagers are more willing to support people and thus they are thinking that their absence in joining more possibly to be criticized rather than urban respondents. Also, no respondents are reported with 'somewhat unlikely' and 'very unlikely' responses while very few are reported in urban context (figure 5.4). Figure 5.5 shows that the likelihood to participate for solving community issues in their villages. In rural areas, 85% and 12.8% are reported that they are very likely and somewhat likely participate for community works respectively while 46.2% and 19.2% respectively in urban areas. No 4^{th} and 5^{th} ratings are found related to rural areas. Majority of urban respondents are thinking that the participation in community works is not an obligation. Both examples exemplify the people's imagination on collective actions and their cooperation in public and social works.

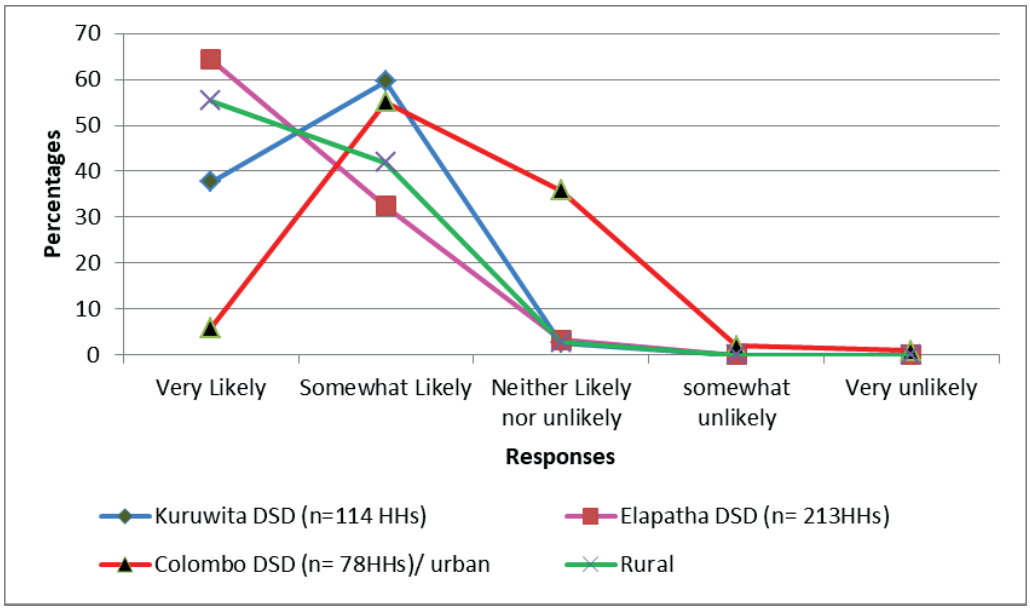

Figure 5.4: Likelihood to criticize when people not participation in community works

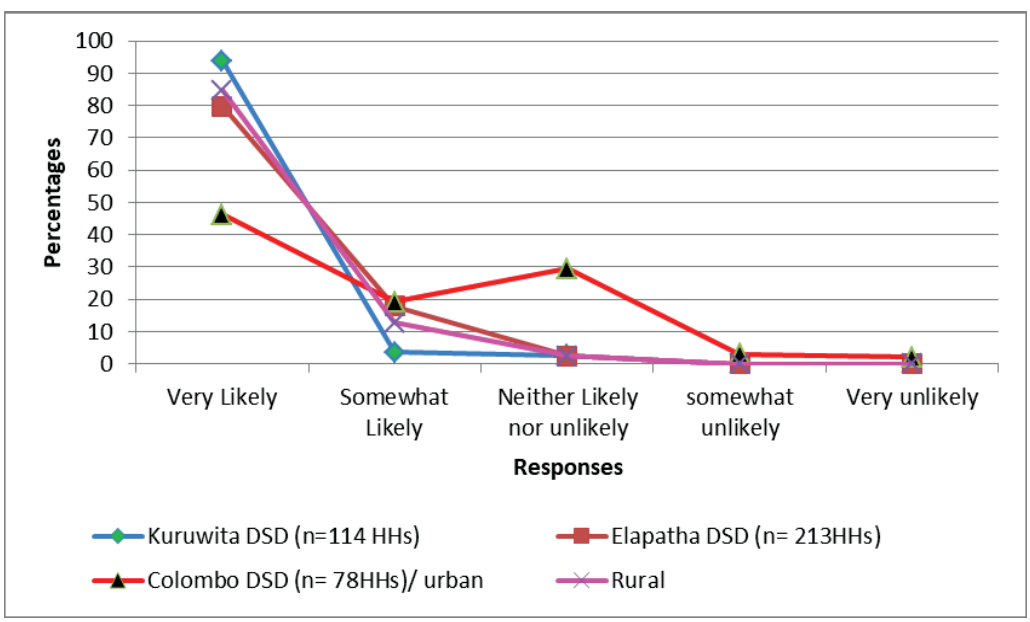

Figure 5.5: Likelihood of corporation to solve community problem in their premises

5.1.4. Information and communication among villagers

In the contemporary societies, sharing and provision of information can be identified as one of the foremost important parts particularly in the disaster events (Jones and Faas, 2017). Therefore, the efficient information provision and sharing has been leading to strengthen cognitive as well as structural social capitals by many folds. In particular, before, during, and after flood inundation phases, sharing and provision of information are identified as foremost important by all the means. This section briefly examines the creation of social capital through information and communication according to the respondents' responses.

Figure 5.6 shows that the numbers of contacts made or received before, during, and after flood inundation phases. They have communicated with others before flood inundation (average, n= 9 and n= 3 in rural and urban areas respectively) and then at during phase the phone communication has stopped. Again, at after phase it has become very normal and increased (average, n= 14 and n= 5 in rural and urban areas respectively).

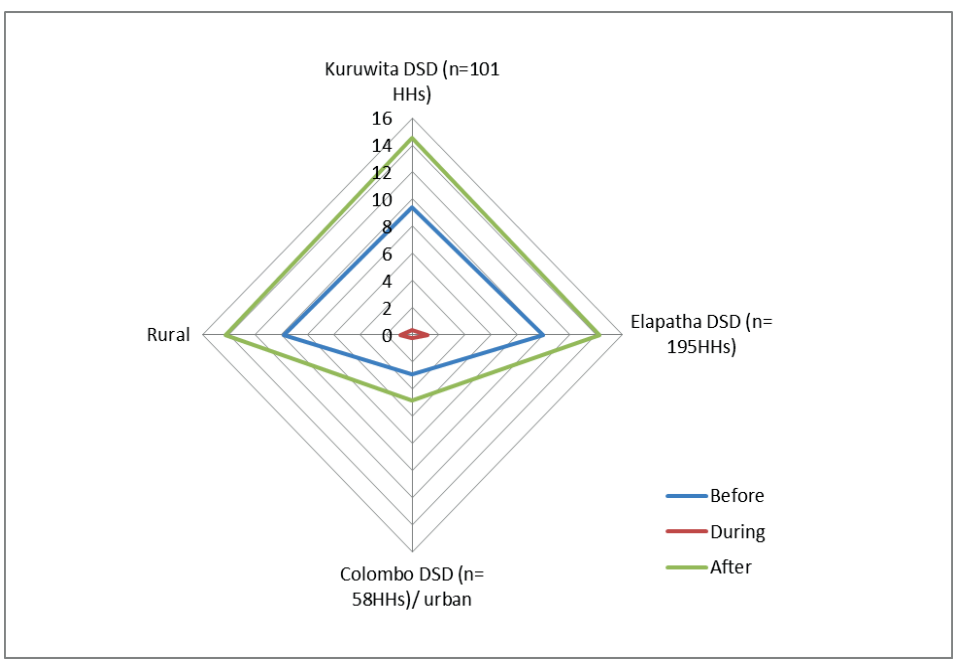

Figure 5.6: Number of contacts received or made before, during, and after flood inundation (considered the average, since it is difficult them to recall the exact #)

In urban and rural areas, some of HHs are found with no phone communications, because they didn't use mobile or land phones and but they have communicated with neighbors. Especially, in rural areas, when the flood inundation

depth is increased, the electricity supply temporary has been stopped. Therefore, they don't have communication with mobile phones. This identified as a big issue, because victims' information and their urgent needs impossible to be informed. Generally urban areas are found to have less communication compared to the rural areas.

The majority of respondents in both Kuruwita and Elapatha DSDs are watching TV news (e.g. everyday 84%, never 12%; everyday 87%, never 10% respectively) rather than listening to Radios (e.g. everyday 42%, never 49%; everyday 39%, never 50% respectively (table A-11, appendix). In urban areas, radio news (e.g. everyday 60%, never 24%) is highlighted compared to TV news (e.g. everyday 17%, never 62%). Regarding the three most important sources of information, Kuruwita, Elapatha, and Colombo exemplified, Relatives-neighbors-friends (53.5%), GND office (23.7%), TV (13.2%); GND office (46.9%), Relatives-neighbors-friends (26.8%); TV (13.2%); Relatives-neighbors-friends (48.7%), TV (21.8%), Newspapers (20.5%) with lesser amount of other sources, respectively. Small changes can be seen among regional contexts. According to the majority of urban respondents, they don't receive information form GND office. However, it is difficult to believe as almost correct information despite each and every GND has their own GND office.

5.1.5. Social cohesion and inclusion among respondents

The notion of social cohesion has been one of the compulsory aspects of collaborative and reciprocal ties, in particular related to social capital. The togetherness and unity also have closed associations with social cohesion. These all aspects may have some of complementary ties among each other in terms of strengthening social cohesion and inclusion. On the contrary, all the communities may have some of exclusions due to many reasons. Because of they are more diverse in income, social status, ethnicity and so on.

According to the results revealed, the respondents of all three DSDs have indicated that their respective societies are economically and socially diverse. For instances, Elapatha and Colombo DSDs exemplified that 4.7% (10 HHs) and 2.6% (2 HHs) the difference is 'to a very great extent' while no responses reported in Kuruwita DSD for this category (see, table A 11-12, appendix 2). Further, Kuruwita, Elapatha, and Colombo DSDs have indicated that the figures; 99.1% (113 HHs), 90.6% (193 HHs), and 93.6% (73 HHs) on the difference is 'to a great extent' respectively. The difference is to 'neither great nor small extent' indicated with 0.9% (1 HHs), 4.7% (10 HHs), 3.8% (3 HHs) in Kururwita, Elapatha and Colombo DSDs respectively. Therefore, it is very clear that their societies are very different

in accordance with their responses. In some cases, the differences among communities have been emerged kinds of problems and also social capital can be decrease due these problems among peoples. In particular, respondents in Colombo informal settlements (e.g. 30.8 %, n= 24 HHs) have urged that the differences may work as causative factors for emerging issues compared to Kuruwita (e.g. 8.8%, n= 10 HHs) and Elapatha (e.g. 7%, n= 15HHs) DSDs (table A-15/1 to A-15/3, Appendixes 5). However, the majority of respondents mainly in rural and also urban areas have pointed out that they didn't experience issues related to socio-economic differences of their communities. Especially, in rural areas, kinds of differences are not mattered for the development and the mobilization of social capital.

I also examined the main two differences of villagers in which posed to make problems among them. For instances, related to Kuruwita DSD, differences in political party affiliations (57%, n= 65 HHs) and differences in landholding (46.5%, N= 53 HHs) possible to make some of issues (table A-15/7-8, appendix 5). Similarly in Elapatha DSD, differences in political party affiliations (64.8%, n= 138 HHs) and differences in landholding (37.6%, n= 80 HHs) are identified as causative factors for making some of problems (table A-15/9-10, appendix 5). Differences in landholding (80.8%, n= 63 HHs) and differences between long-term and recent residents (59%, n= 46 HHs) are indicated as main reason for making problems in urban areas (table A-15/11 to A-15/12, Appendixes 5). All the urban and rural respondents have urged that abovementioned causative factors didn't lead to make any kinds of violence in their areas.

In general, they have get-together with others in order to have food and drinks in their premises or any other public places as part of their cohesion. The respondents of Kuruwita, Elapatha, and Colombo DSDs have had meetings with others on average 3.2, 2.8, and 1.7 times in the immediate past month respectively, when the survey is conducting (average made the decimals). Some of respondents had meeting up to 6 times per month in Kuruwita and Elapatha areas while 3 times maximum in urban areas (tables A-15/13 to A-15/18, appendix 5). More than 95% of respondents in all the DSDs have noted that peoples who met in their meetings were diverse in caste, economic status, and social status but they were same in religious background in rural areas while all were diverse in urban areas.

Figure 5.7 illustrates that the feelings of safe when respondents are at their homes alone. The notion of feeling safe was very sensitive as the majority of respondents (around 60%) were females. Particularly in rural areas, most of the respondents have responded that they are feeling very safe (e.g. Kuruwita 85.1%, n= 97 HHs; Elapatha 75.8%, n= 161 HHs) compared to urban areas (e.g. 5.1%, n= 4 HHs). Colombo has indicated much on moderately safe feelings (e.g. 66.7%, n=

52 HHs) while Kuruwita (e.g. 10.5%, n= 12HHs) and Elapatha (e.g. 9.9%, n= 21 HHs) represent quite low rates. Some of them have uncertainty about feeling safe may be that came up with neither safe nor unsafe (e.g. Colombo 17.9%, n= 14 HHs; Kuruwita 4.4%, n= 5; and Elapatha 5.2%, n= 11 HHs).

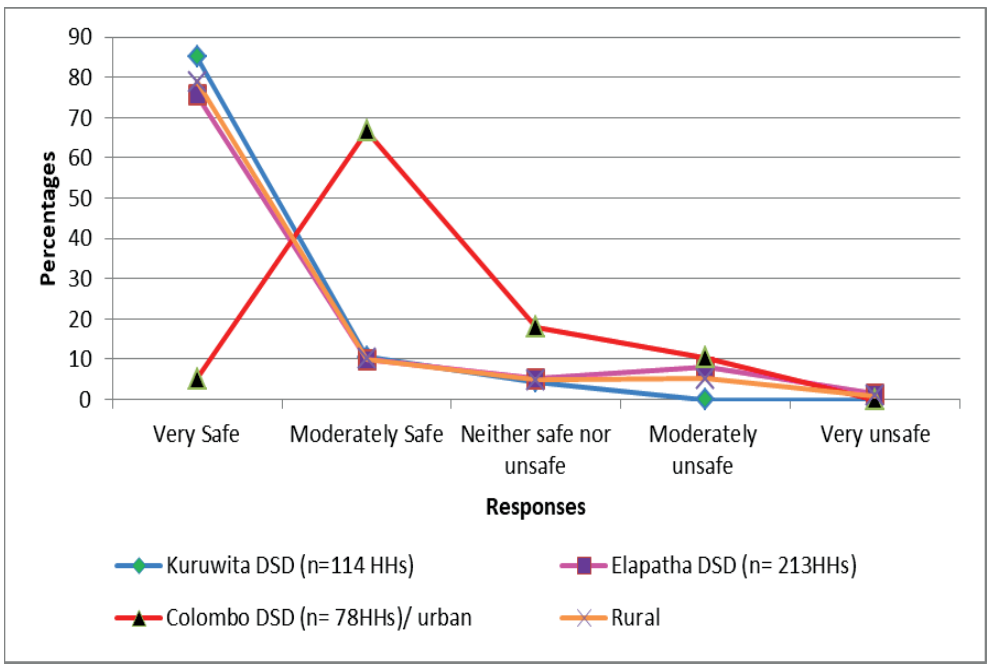

Figure 5.7: Feeling safe when they are alone at home

Regarding the feeling of moderately unsafe and very unsafe, urban respondents have reacted that 17.9% (n= 14 HHs), 10.3% (n= 8 HHs) while Elapatha represents 8% (n= 17 HHs), 1.4% (n= 3HHs) respectively. None of respondents found in Kuruwita DSD in related to those two categories. Compare to urban context, rural areas exemplified more safe feelings. Therefore, rural villagers have rich bonding, bridging, and linking ties and enhanced social capital mobilizations. Regional differences also can be found in all the areas.

5.1.6. Towards empowering people and political actions

The famous conception of empowering people may has very broad meaning in terms of expanding their assets and capacities to involve with life changing strategies including mainly participation, influencing and controlling (Grootaert, *et al.,* 2004). In particular, empowering poor people and open new trajectories for their development are more influential to remove their livelihood barriers. Political actions such as campaigning and voting elections may have more prowess to do so. In this study I only included most important and key aspects to investigate how

these conceptions are worked in the flooding events.

The feeling of happy implies many of their life satisfactions and livelihood conditions. Figure 5.8 shows the respondents' reactions about their happiness in DSD level. More importantly, majority of respondents of Kuruwita and Elapatha DSD have reacted that they are feeling very happy even they have been living with many difficulties (e.g. 51.8%, n= 59HHs; 60.1%, n= 128 HHs respectively) compared to urban sector (e.g. 2.6%, n= 2 HHs). And also, considerable HHs numbers have reported with moderately happy in Kuruwita, Elapatha, and Colombo DSDs (e.g. 43%, n= 49 HHs; 32.3%, n= 69 HHs; 25.6%, n= 20HHs respectively). Predominant number of respondents have reacted with neutral (e.g.15.4%, n= 12 HHs) in urban areas while 3.8% (n= 8 HHs) in Elapatha areas. Furthermore, considerable number of respondents have pointed out that they are moderately unhappy in Kuruwita, Elapatha, and Colombo DSDs (e.g. 3.5%, n= 4 HHs; 3.8%, n= 8 HHs; 41%, 32% respectively). Some of them have responded that they are very unhappy, those who are in Kuruwita and Colombo DSDs (e.g. 1.8%, n= 2 HHs and 15.4%, n= 12 HHs correspondingly).

Generally, people who are living in urban informal settlement areas have some of unhappy feelings about their circumstances and on everything and most often represented quite aggression. This is because, they urged that no one helped them to solve out their problems and a range of economic hardships. Therefore, they have to do even such illegal things in order to earn money for livings. Many of female respondents urged that they are the breadwinners of their families and they have many responsibilities to secure their families. Because of, in many cases, their husbands have separated from them leaving wives with their children or otherwise they are in custody due to many underworld activities including drug trafficking.

Another more important aspect is that the ability to make crucial decisions to change their life towards success. Many respondents in all the DSDs have reacted that it is totally unable to change their lives (e.g. Kuruwita 33.3%; Elapatha 31.9%; Colombo 24.4%, figure 5.9). Similarly, according to figure 5.9, many of them have responded that their feeling on changing course of their lives is neither able nor unable (e.g. Kuruwita 51.8%; Elapatha 29.1%; and Colombo 42.3%). Because of they don't have proper guesstimate and also difficult to make it on their current circumstances. And also the majority of urban respondents are thinking that it is mostly unable to change the life (e.g. 42.3%). More importantly, 26.3% of Elapatha respondents are feeling that mostly able to change life while Kuruwita (7%) and Colombo 5.1% represent lower amounts. And also, 1.8% of Kuruwita areas have responded that totally able to change their life and no respondents found related to the rest of DSDs.

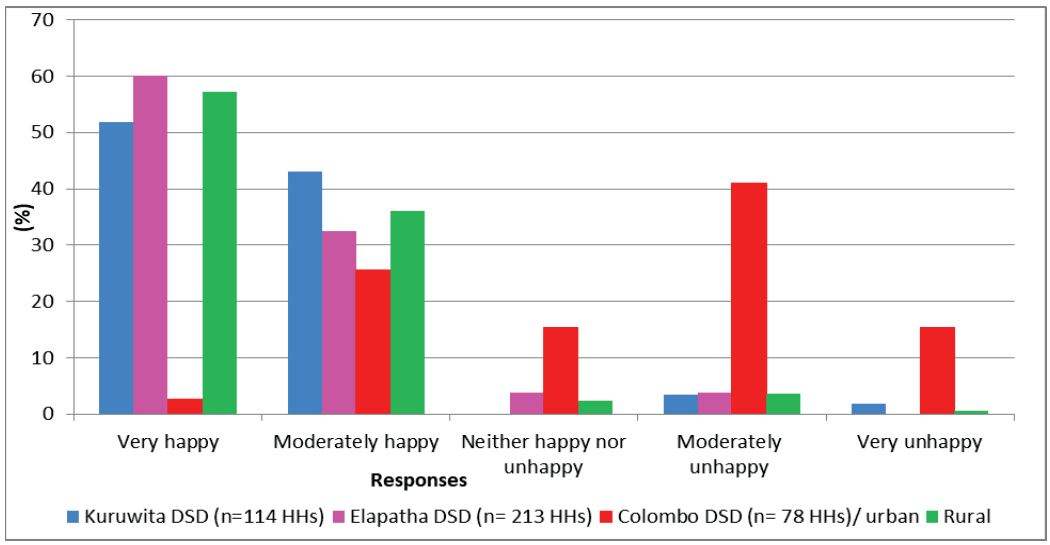

Figure 5.8: Feeling happy in day-today life

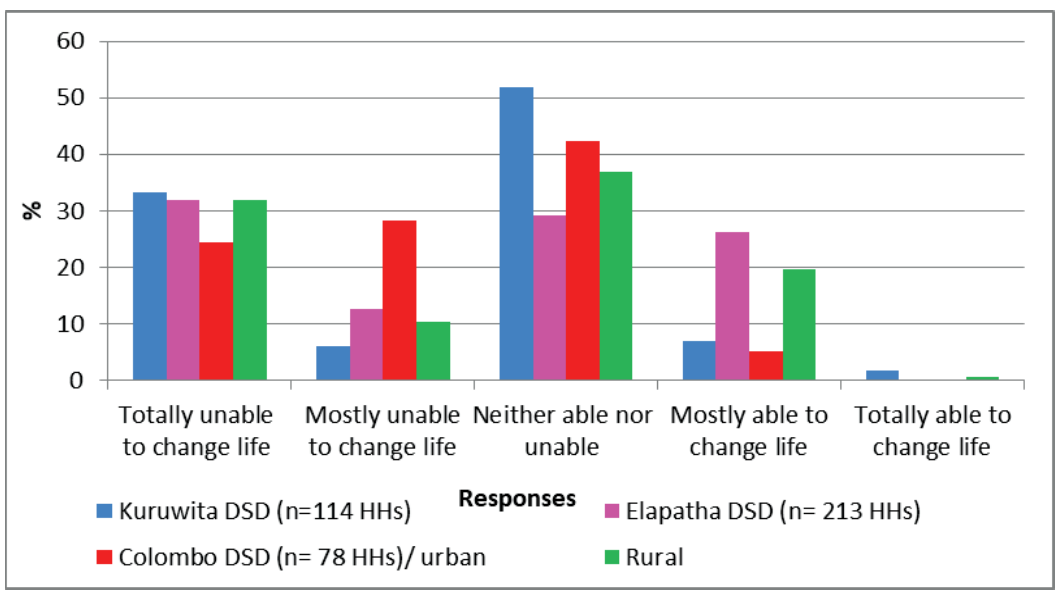

Figure 5.9: Feeling of self-power to make decisions to change the course of life

Regarding the people's ability to make their villages and neighborhoods better places to live, respondents have reacted with quite negative feelings. For examples, considering they could make 'a big impact', Kuruwita, Elapatha, and Colombo areas, reported with 11.4% (n = 13 HHs); 32.9% (n= 70 HHs); 5.1% (n= 4 HHs) respectively (tables A-16/1 to A-16/12, appendix 6). The majority of Kuruwita and Elapatha HHs have responded that they can only do 'a small impact' to change their villages (e.g. 56.1%, n= 64 HHs; 42.3%, n= 90 HHs respectively) and urban areas indicated 26.9% (n= 21 HHs). And also, the predominant numbers of respondents in urban areas have reacted that they can't do any impact (no impact)

to change their premises (e.g. 66.7%, n= 52 HHs) while Kuruwita (31.6%, n= 36 HHs) and Elapatha 24.4% (n= 52 HHs) exemplified relatively lesser responses. Villagers' collaboration to make petitions to authorities in order to improve villagers' facilities is very negative. For instances, the almost all the respondents in Kuruwita, Elapatha and Colombo DSDs have pointed out that they didn't make any effort to make petitions on their needs (e.g. 96.5%, n= 110 HHs; 87.3%, n= 186 HHs; 94.9%, n= 74 HHs correspondingly, (tables A-16/1 to A-14/12, appendix 6). This is because they know that their petition efforts could not be successful. On the other hand, they have been used their vote power to select all the political bodies during their elections. They have used their democratic power of voting elections at past elections (e.g. Kuruwita 97.4%, n= 111 HHs; Elapatha 99.1%, n= 211 HHs; and Colombo 97.4%, n= 76 HHs) (table A-16/4, A-16/8, A-16/12 respectively). This implies that their abilities of electing appropriate members for the parliament and party politics is concerned subject in villages. However, villagers' hardships and village level difficulties have still been persisting. Abovementioned aspects have intertwined with the structural and cognitive social capital notions. In contrast, above discussed social capital advancements are in related with their daily life styles have crucially been influenced to the critical situations they face similar to flood inundation.

5.2 Traditional social capital (TSC) in the flood inundation events

5.2.1. Past experiences of social capital

In accordance with the extant literature, early societies of Sri Lanka have had very close relations and interactions with each other in terms of different cultural and social practices. Sri Lanka prominently exemplifies for rich cultural values (e.g. Daskon and Binns, 2010) and for rich indigenous knowledge (e.g. Ulluwishewa, 1993) particularly in the Asian region. Traditional social capital[53] has been intertwined with these values. Therefore, by this part, I examine the role of traditional social capital of the communities and their behaviors in the context of natural disasters such as the flood inundation in rural regions of Sri Lanka. Because of none of historical evidences found related to urban areas. In contrast, country's traditional socio-cultural values and practices (e.g. Native Ethos) have been influenced in terms of having better collaboration practices to conquer the impediments and hardships in flood disaster situations.

[53] This part has already published (e.g., Karunarathne and Lee, 2019).

Villagers usually take advantage of their own wooden boats to move out and bring household items form isolated low-lying households even including pets like dogs and cats. They have used the similar ways to evacuate family members and neighbors from inundated areas. Further they are very happy to stay at others houses (providing sheltering before and during the flood inundation) by sharing their emotional helps, cooking and eating together with relatives and so on. This kind of boding social capital has particularly been fostered by the kinship ties. Most of respondents are quite familiar to swimming and boat riding particularly in the flooding waters and they have so many experiences on flooding situations. More importantly, their lives have been interrelated with the nearby rivers. Their main livelihood strategy is gem mining particularly in the river bed which is known as *"Ganga Edeema"* in Sinhalese. Therefore, it is noted that they utilize similar skills for disaster response by bonding social capitals. One of the respondents (86 years old, living in Raddella GND) stated his past experiences as follows;

"The flood inundation is not an especial event for us. At that time (60 to 70 years back) we didn't have transportation, electricity, telephones, tar roads, televisions, and many others…but we managed our lives well with many economic hardships. Also, we had faced many flooding events, we know when flood comes, we know the places where inundate of our village, we had our own boats, we lived very harmony manner with our neighbors, we helped and shared each other with our resources when unexpected encounters come, also our lives had interlaced with our traditional customs, and we secured with them…."

More important implication from the above statement is that they have been managing inevitable natural events very sufficiently with the capability of traditional ties and traditional social capital even in a low level of infrastructure establishments. Similarly, Marcum, Wilkinson, and Koehly (2017, p.117), revealed that *"the availability of extended kinship ties may offer families a wellspring of social, as well as instrumental, support that can be accessed during disasters"*. Many other respondents who are living in different GNDs and belonging to different communities also support that strong societal ties and extended kinship ties that have helped them successfully cope with natural disasters. One respondent, living in Dimiyawa village (88 years old, Raddella GND) stated his experiences about one of the critical past floods as follows;

"We experienced torrential heavy rains during the whole day, we expected that the definite flooding would come by the next day, but unfortunately, at the midnight we experienced flooding, we had to move out our belongings as soon as possible to

uplands, we lighted the bundles of already prepared dried coconut leaves called 'Pandam' (in Sinhalese), using our boats we brought out all the belongings from our houses collaborate with neighbors and evacuate all the villagers who gone under inundated, the next day the roof of my house was disappeared by inundation with other nearby houses as well …"

Regarding midnight floods, the villagers provided with end-to-end helps and evacuation services with each other as collective actions. That story implies that the role of stronger boding social capitals. Also it may provide a preeminent instance for more resilient of traditional social capital. Another respondent (82 years old, living in Owitgama GND) introduced his past experiences on cooking for others in an extreme flooding event as follows;

"I remembered that with my Mum, we stayed at a relative's household had located at an upland in the village, there were six families stayed at the same house during the five days' flooding, my mum cooked everyday rice, jackfruits, Pol Sambol (one of delicious Sri Lankan coconut curries) and curries with other ladies for all families and also provided with many other displaced peoples as well…. "

This case showed how bonding social capital works when people utilize their resources for others during inundation. Fostering collaborative works help build solid network relations and interlace them together by making them much stronger in an emergency of flooding events. This kinds of collaborative practices has been maintained until the present, which might be a remarkable example for years. These experiences can be actually seen along the past flooding events.

Uphoff and Wijayaratna (2000) explained how this activity help to stronger village level social capital and demonstrated as the combination of both structural and cognitive forms of social capital. Obviously, their activities have represented the collaborative nature of traditional social capital which intertwines with their norms, values, beliefs and customs in a complementary way. One female respondent (81 years old, living in Miyanadeniya GND) explained her experienced on village charity works, noted as below;

"We always followed village level customs and precedents, worked together for helping others when they need any kinds of helps, at least one member (most probably more than one) from a household must participated for village charity works, these experiences were very fruitful, we also received many helps from others in difficult situations, we shared our emotions with others, we daily meet with our villagers at the common bathing place (called Podu Linda or common

well /or Nana peella), we shared village information with each other, we always up dated with villagers…"

Particularly, village level associations and organizations have been interlinked with the Buddhist temples and always having assistants and guidance from Buddhist monks. Their traditional socio-economic networks have been solely depended on those village associations (Table 5.1, shows the present village associations). Therefore, villagers have presented good solidarity, norms and trust among associate members which can be identified as most influential factors for bolstering each other, forestalling forthcoming adverse effects, and reviving village level livelihoods, therefore for example (Uphoff and Wijayaratna, 2000), sharing resources and goods are identified as collective than just individual. In this context, it is reasonably argued that Sri Lanka may be at the forefront of interlaced community relations and collaborative charity works compared to other developing countries. Respondents highlighted that the significant of village level traditional social capital when they are isolated by the encircled floodwaters.

5.2.2. Legacies of traditional Native-ethos and floods preventive apparatuses

Native Ethos shows by different kinds of socio-economic practices and values highly related with the Buddhist religious practices. Buddhism, as a religion which has been close interactions and trade-offs with the society, and also as a philosophy it has been linked with 'the traditional temple education' systems which enriching many socio-cultural values, love and kindness, disciplines, rituals and norms with many kinds of customs. This traditional relationship have been urged people to be educated by attending the traditional school system called 'Daham School' (*DAHAM PASALA*) which has been conducted by the village Buddhist temple. According to Uphoff and Wijayaratna (2000), their norms and beliefs, traditional customs have strongly been interlaced with the village lives and the social capital. This system has also been linked with the agriculture through traditionally contiguous system to villagers called "*WEWAYI (tank) DAGEBAYI (Stupa) GAMAYI (village) PANSALI (temple)*". These kinds of profound and rich systems have had been made some influences for proliferating of the quality of rural livelihood. Sri Lankan traditional "Village-agro-eco-system" is also can be considered as one of the influential basics as well causative factors for making of perfect traditional socio-economic networks. According to this system, each and every household has their own cultivations particularly in the home gardens and these foods have been fulfilled their day today needs as well as helped to tolerate

external shocks such as food shortages. Because, according to Marambe and Silva (2012), that system comprised crop cultivation, animal husbandry, fisheries, and forestry, collectively provide almost all the foods and other needs of the inhabitants. This village production system produces many resources for securing their livelihoods, and also enriching their social capital. In contrast, they have been sharing their harvests with their neighbors and villagers as the ways in which traditional norms and customs established. Therefore, their traditional social capital and socio-economic networks much stronger particularly in the disaster situations. In contrast, the evidences of this work suggest that their networks are much prowess in the flood inundation events. Similarly Turner, Subak, and Adger (1999) revealed that the degree of social cohesion helps to preserve communities and some of support and reciprocity networks are more effective than the natural disaster programs of even the wealthiest countries. This insight manifested that how early rich and interlaced social practices help to mitigate natural disaster events and preserved their lives. Because of the geographic and spatial distribution of ties is often a key variable in the provision of social support in disaster contexts (Faas and Jones, 2017, P.13).

In accordance with their experiences and traditional knowledge, they can make the exact guesstimates about coming flood events and getting ready for them. For example, in the rainy season (within the South-West monsoon), they know that (People who are living in both Elapatha and Kuruwita DSDs), there is a special flooding event call "45 days flood" (in Sinhalese "*DINA HATHALIS PAHE WATHURA*") which comes 45 days after the mid of April (after *SINHALA ALUTH AWURUDU* festivals in Sri Lanka), each year in May or June. They have investigated these patterns since decades. Another important guess is that they have some of "Land Marks" which are located in the low-lying areas of their villages. If some of these Land Marks inundate by a one day frequent rainfall, they definitely know that in the coming day will inundate the premises of their households. Therefore, each and every person in the village often pays their attention to these 'Points'. The foremost important thing behind these traditional practices is that those help to secure villagers lives and reduce the adverse effects of flood inundation. In contrast, the villagers have more significant traditional practices which are possible to be identified as "perfect metaphors" for forestalling flood devastations. One of the happy tales of this study found is that the villagers have been used their traditional knowledge for disaster prevention until yet. In the current flooding events, dozens of newly manufactured boats have distributed to alarming areas which are capable to carry five to seven peoples at once time by many organizations such as the disaster management center (DMC), Red Cross, and other donors. Despite, in the traditional societies, they had to create their own

boats for evacuation villagers. These traditional experiences and stories are very significant for the current study. One respondent (90 years old, living in Theppanawa GND) described his experiences in making wooden boats as follows;

"I have good experiences in making wooden boats with my father, first we find appropriate trees for boat building, they must be grown well and very strong with light-weighted, also the shape is very important, after cutting the tree we painted it with traditional oils and dried out with sunlight more than two months, so then begin to dig the bed of boat, I learned the ways of making wooden boat from my father, still I have my own two boats. Those capable to carry five to seven people at once a time, we have evacuated our neighbors a plenty of times in the flooding events, at present I can't do anything…."

Making of boats at that time is one of the major challenges in which flood-effected peoples faced. However, the traditional technologies were much rich enough to select appropriate woods and create wooden boats which were sophisticated and appropriate to carry many peoples at once a time. The villagers consider that traditional wooden boats are as more important property for their life styles. In most of the cases, each and every households has own made wooden boats which enable them to evacuate at any sudden encounter they face or help to other victims (Figure 5.11). Therefore, their knowledge and skills have been more enviable along the disaster prevention process.

The architectural design of households is also one of the crucial apparatuses in the rural villages. For example, in the regional areas, most of the households have built more than 50 to 60 years ago. Their shape, built material, and sizes are almost differing from the present houses and also they still have some of astounding rocky feature as well. In contrast, traditional societies, they didn't have enough financial background to build houses with many-stories. In accordance with their needs, particularly meeting with the flooding situations, they have built 'an upper part' of houses by using woods under the same roof called "*Soldaraya*" (Figure 5.10). This wooden part is not appropriate and applicable for the houses in which undergone with full inundation. The *Soldaraya* can be appropriate for the households which are inundated with up to 5 to 7 feet in depth. A considerable number of sampled households are reported with this special structure. During the flooding, family members and the invited relatives or neighbors are used to stay this stage. The foremost advantage of this stage is that they moved up and installed all the belongings there and they don't need to evacuate during the flooding.

Figure 5.10: Upper left panel: Access to wooden *Soldaraya*; Upper right panel: Basement of a Wooden *Soldaraya.* Bottom left panel: Explaining boat-making expertise; Bottom right panel: Explaining past flood experiences

Figure 5.11: Upper left panel: Wooden boat – Kahawatta GND; Upper right panel: During the flooding, Karangoda GND. Bottom left panel: Reciprocal supporter; Bottom right panel: Readying to move out amid inundating, Karangoda GND.

According to the past knowledge-practices amongst elders which associated with traditional practices, all the components had integrated together as a village system in terms of fulfilling complementary needs, in the TSC context. Thus, the definition of TSC comprised village socio-economic associations and their networks (e.g. reciprocal ties); native ethos including cultural heritages, norms and values, customs, rituals and religious practices; tangible values (e.g. resource exchanging including foods, goods, other basic needs and sheltering etc.); intangible values (e.g. sharing traditional knowledge and apparatuses, emotional helps etc.). TSC components are complementary and impossible to disentangle.

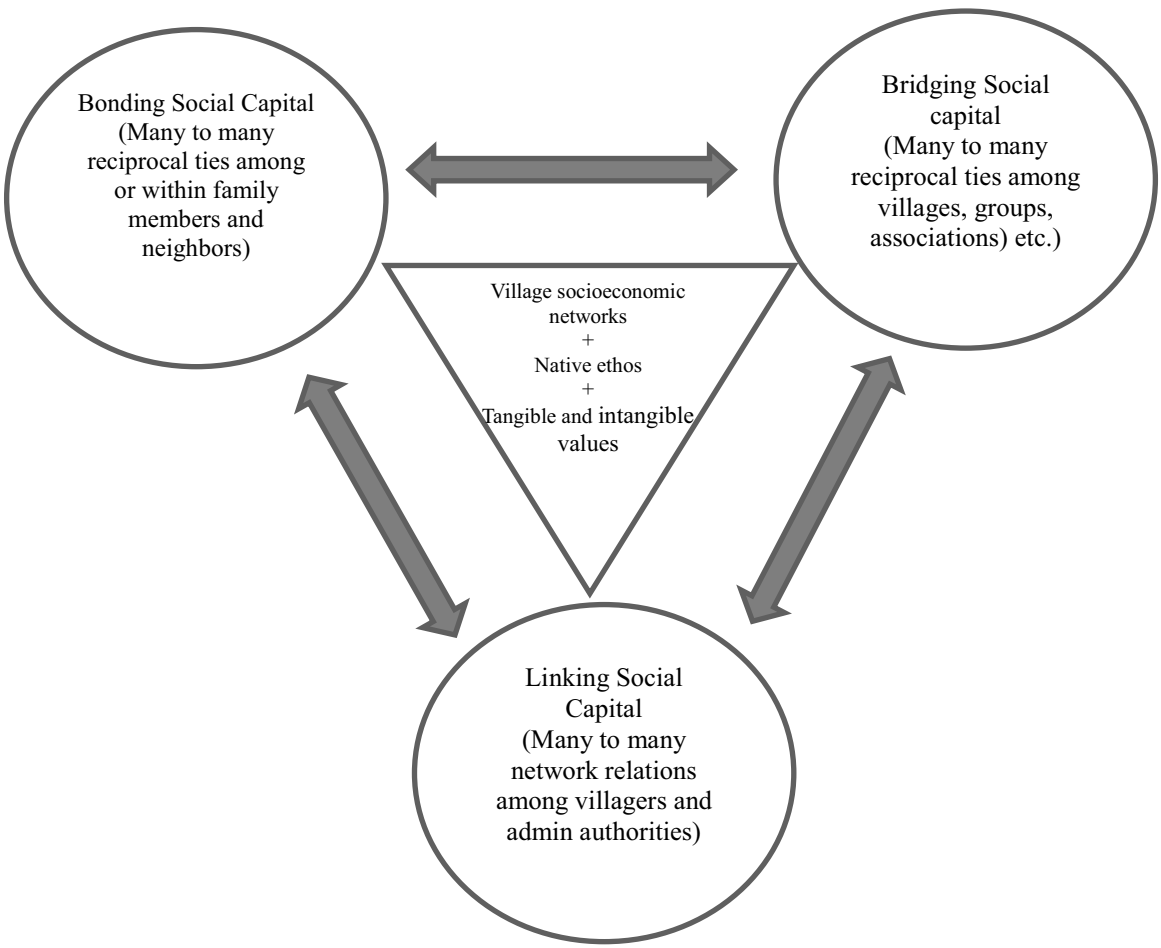

Figure 5.12: Complimentary associations and nature of traditional social capital (TSC).
Source: Modified from Karunarathne and Lee, 2019.

On this context, I define TSC as a traditionally integrated village system which interlaced with village lives in terms of helping each other (e.g. mutual advantages) and revivifying their livelihoods when they meet adverse effects or some paradoxical situations. I focus my attention on this traditional village system and their practices in past flooding events under the scholarship of bonding, bridging, and linking ties (Figure 5.12). Moreover, TSC metaphor may be worthwhile and instrumental for other researchers in order to understand the rudiments and practices of their cases as none of empirical studies are found on the examining TSC practices.

Some of old aged actors in village socio-economic networks are the vanguards of making their networks stronger by interacting often with network actors a plenty of ways. This study revealed undeniable evidences on behaviors of these actors and their preeminent roles. Enviable nature of relationships is pivotal important in the recovery situations of flood inundation events. Therefore, socio-economic network can be identified as a perfect proxy in village level worries recovery. Another important aspect of these traditional networks is that the interlaced nature of their associations often relied on the reviving of effected livelihood by resources sharing/mobilization and helping many ways each other as much as they can. The traditional associations of rural communities are being persisting yet even in a situation of the communicative apparatuses of traditional networks have been superseded by the sate-of-the-art telecommunication technologies at present. This is because, the traditional networks paid enormous impacts on the securing and coping their members in terms of the provision of necessary foods, goods, money, information, emotional supports, housing during flooding, rescue operations. In the inundated villages, they used their hoses which are located in un-inundated lands to cook meals for all the victims in such a collective manner with huge cooking containers and provided with them the foods.

Foremost important thing behind village life style is that they have stockpiled food in their houses ‘more significantly as a buffer’ against food shortages during rainy seasons in particular for flooding events. Stockpiled foods (paddy collection, tried jackfruit seeds storage missed with sands for examples) and resources have often been shared among network actors, identified as live-long legacies in village lives (figure 5.13). The particulars of traditional socio-economic networks in which related to the egalitarian nature have long been intertwined with the native ethos. In contrast, their reciprocal exchanges are germane to traditional social values, norms, customs and rituals tec. Moreover, the findings revealed that Sri Lankan traditional

socio-economic networks may be a paradigmatic case in traditional social capital and have often been cementing with strong foundation to the extant and existing socio-economic networks and social capital metaphors. Therefore, this study also will be advanced by demonstrating a fresh impetus to the traditional socio-economic networks, analyzing their behavior in the flooding events.

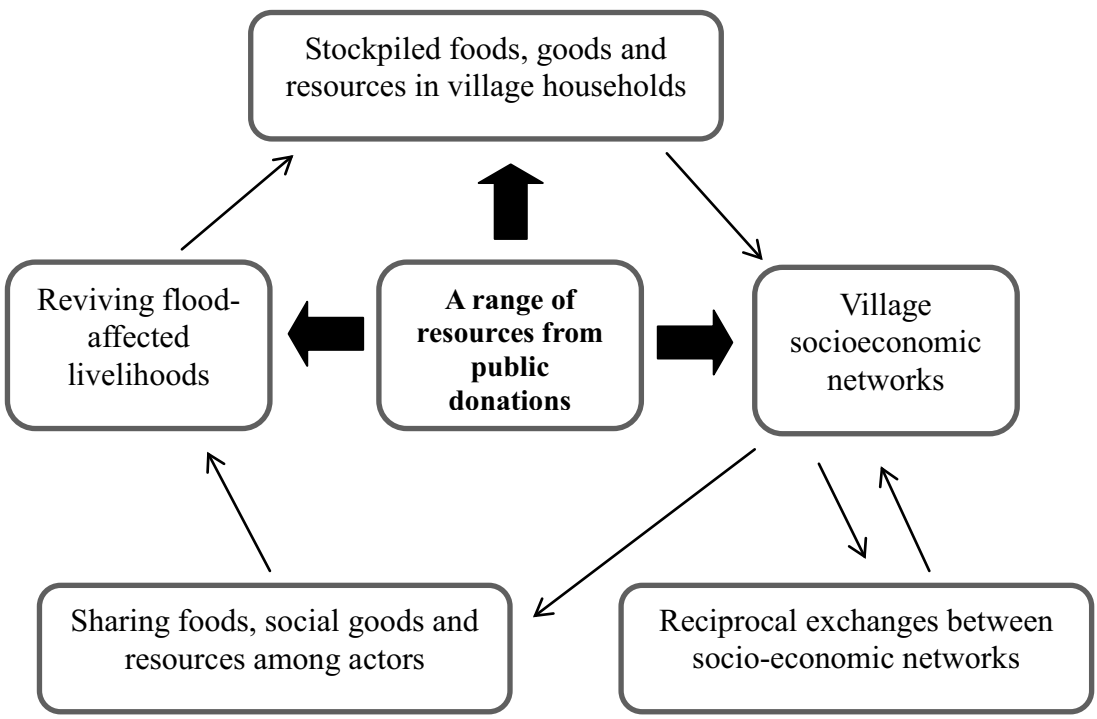

Figure 5.13: Reciprocal exchanges and village flood-affected livelihood securing system (Source: Modified from Karunarathne and Lee, 2019).

More than 90% of sampled households belonged to one or many social associations, and the head of household or the rest of the members hold these memberships. The purposes and missions of village associations are diverse. Their ultimate goal is unique in that it is the provision of a range of services and resources for villagers in accordance with fulfilling their needs (Figure 5.13). Public donations are pivotal in the livelihood revivifying process. More importantly, some associations are related with village customs and rituals.

Internally migrated woman (77 years old, living in Dambuluwana GND)

explained quite different experience with village cooperation as follows;

"My birth place is Matara (one of southern cities of Sri Lanka), I migrated to Ovitigama 54 years ago, after I got married. After two months, I experienced a mass flooding event and that was first time in my life, we lived in a separate house near to a paddy filed, before began flood inundation my husband went to help his parents' house, I was alone and feared, no one helped me, when my husband backed to home our house almost encircled by floodwaters…."

Some of internally migrated women also described their difficulties experienced with new community relations. It is obvious that internally migrated women didn't have much community collaborations within first few years with natives and had experienced isolations from the community networks particularly in flooding events. Geographical and physical barriers of villages also have negatively influenced the maintaining community collaborations during adverse events. Two female respondents (79 and 76 years old, living in a remote area of Kahawatta GND) explained that their uplands houses were isolated by a past flooding event and they received others' supports (e.g. foods and basic needs) after two days. Because of the velocity of floodwaters at nearby places is very high due to the rough and precipitous terrains. Similarly, a male respondent (81 years old, living in Haldola GND) described one of his stories about boat riding in a past flooding event. He had faced a range of critical difficulties as the access paths were blocked by floating debris, trees and bushes at the inundation depth of 15-20 feet. The mobilization of TSC had confined by the locational barriers of remote rural areas. Because of, the provision of supports is solely depending on the spatiality of ties in disaster situations (Faas and Jones, 2017, P.13).

The study identified the traditional social capital as crucial for building and strengthening social ties and reinforcing collective action and collaboration among villagers, in addition to their altruistic nature. Additionally, the study suggests the existence of complementary links among the basic forms of the traditional social capital (bonding, bridging, and linking) based on respondents' experiences. Therefore, the practices of the traditional social capital proxies can be identified as more important and worthwhile buffer for the sustainable livelihood development and flood disaster resilience. This chapter also revealed that the rural areas have very rich and pervasive social capital legacies compared to the urban context.

Chapter 6. Characteristics and geographies of social vulnerability to flood inundation

With referenced to the extant literature, the conception of social vulnerability is multidimensional and a range of theoretical perspectives have been evolved in the epistemology of vulnerability notion. The majority of vulnerability applications have been considered their own geographical settings and related variables in term of examining disaster induced social vulnerability. This is because the social vulnerability is solely depending on the geographies of (e.g. place-specific) disaster circumstances, their own social and environmental indicators and conditions (e.g. Adger, 1999; Cutter, *et al.,* 2003). In contrast, by examining the empirical data and field observations, I identified and recognized that socio-economic networks and related social capital metaphors have been more instrumental in terms of ameliorating adverse effects of flood inundation, reducing vulnerability, and revivifying livelihood in the Sri Lankan context, as thoroughly explained in the 4th and 5th chapters. And also, it is theorized that the developing country like Sri Lanka has its own and unique altruistic nature of helping each other particularly in the adverse situations (e.g. when they face unexpected encounters) through different egalitarian socio-economic networks and its traditional base as well as their knowledge practices (e.g. Karunarathne and Lee, 2019). In this context, by examining a range of vulnerability causative factors (e.g. variables) in which used by empirical applications and extant literature, I identified more influential variables (n =31) under five key components for the development of Multi Facets Composite Social Vulnerability Index (MFCSVI) as explained in 3rd chapter. Six composite indexes are calculated according to the factor weighting procedure, and compared the revealed results with the calculated static vulnerability index which is based on IPCC vulnerability framework (e.g. Frazier, *et al.,* 2014).

This chapter has complied as follows; the next section examines the results of MFCSVI, in accordance with Kuruwita, Elapatha, and Colombo DSDs' level including their respective households, GNDs and overall perspectives. The second section discusses the geographies and spatial patterns of vulnerability indices by using different mapping approaches.

6.1. Measurement of multi-facets composite social vulnerability to flood inundation

The results of Multi Facets Composite Social Vulnerability Index (MFCSVI) represent from W1 to W6, in which calculated based on the key vulnerability components and their respective weighting schemes as described in chapter 3. The main intention of weighting the cumulative normalized values of each component was to emphasize the influence of key components to the MFCSVI. By contrast, regional planners and policy makers need to examine the social vulnerability situations in different point of views and angles for their planning and policy establishment purposes. For example, regional infrastructure planner might deem to emphasize the physical components of social vulnerability and it may more important him to consider the index W3. More importantly that regional infrastructure planner also considers the rest of key vulnerability components as well, but with lesser emphasizing. Similarly, other planners (e.g. tourism, settlement development, ecological, road development etc.) might consider to emphasize other key vulnerability components as well. On the other hand, someone could be considered the similar influence from all the vulnerability components and the balance weight approach (W1) may be best choice for him. Therefore, different vulnerability indexes and their results will be benefitted for different purposes in terms of planning and policy making objectives. More importantly all the approaches have considered all the vulnerability variables (n=31) for their preliminary calculations. Therefore, all the indexes represent the exact social vulnerability situations of each sampled household of the study.

6.1.1. Social vulnerability to the flood inundation - Kuruwita DSD

The one hundred and fourteen sampled households (HHs) are belonged to 8 inundated GNDs in Kuruwita DSD are considered. The vulnerability values of Kuruwita GNDs are calculated by averaging vulnerability values of each related household. Table 6.1 illustrates that the different vulnerability indicators of each sampled GND in Kuruwita DSD. In contrast, from W1 to W6 to indicate the vulnerability indexes in which calculated based on MFCSVI approach. ESAC depicts the IPCC vulnerability framework based typical vulnerability index which is used to compare the MFCSVI results. According to the indexes of W1, W2, W4, and W5 (e.g. 0.54, 0.60, 0.63, 0.75 respectively) Kitulpe GND can be identified as the most vulnerable GND among Kuruwita sampled GNDs.

Table 6.1: Vulnerability of Kuruwita sampled GNDs according to different indexes

GND name	Vulnerability Indexes / Scores						
	W1	W2	W3	W4	W5	W6	ESAC
1. Kitulpe	0.54 (0.324/0.754)	0.60 (0.283/0.93)	0.46 (0.231/0.690)	0.63 (0.457/0.774)	0.75 (0.539/0.956)	0.34 (0.149/0.587)	0.45 (0.229/0.715)
2. Ihalagama	0.26 (0.034/0.561)	0.27 (0.025/0.496)	0.36 (0.127/0.545)	0.41 (0.062/0.748)	0.34 (0.081/0.620)	0.25 (0.112/0.887)	0.21 (0.01/0.575)
3.Galukagama	0.30 (0.010/0.597)	0.36 (0.028/0.772)	0.37 (0.03/0.689)	0.48 (0.172/0.781)	0.30 (0.011/0.686)	0.30 (0.03/0.585)	0.22 (0.014/0.514)
4.Theppanawa	0.45 (0.351/0.60)	0.44 (0.273/0.77)	0.55 (0.411/0.703)	0.56 (0.441/0.714)	0.59 (0.501/0.696)	0.27 (0.106/0.49)	0.45 (0.35/0.679)
5. Pahala Kuruwita	0.30 (0.04/0.646)	0.32 (0.078/0.803)	0.35 (0.021/0.60)	0.44 (0.045/0.748)	0.44 (0.275/0.758)	0.24 (0.068/0.558)	0.23 (0.076/0.578)
6. Miyanadeniya	0.49 (0.193/0.875)	0.40 (0.026/0.818)	0.60 (0.335/0.914)	0.52 (0.16/0.843)	0.64 (0.346/0.806)	0.37 (0.018/0.998)	0.47 (0.172/0.811)
7. Pahalagama	0.36 (0.237/0.483)	0.33 (0.152/0.609)	0.51 (0.374/0.671)	0.42 (0.181/0.674)	0.53 (0.477/0.619)	0.24 (0.125/0.508)	0.34 (0.225/0.469)
8. Ovitigama	0.44 (0.021/0.868)	0.40 (0.002/.0.719)	0.55 (0.133/0.986)	0.48 (0.021/0.989)	0.57 (0.32/0.748)	0.36 (0.014/0.719)	0.46 (0.156/0.775)
Average	**0.39**	**0.39**	**0.47**	**0.49**	**0.52**	**0.30**	**0.35**

Notes: W1- Balance; W2 - Socio-demographic based; W3- Physical based; W4- Financial based; W5 - Health based; W6 - Networks and social capital based; ESAC- IPCC framework based index, (with Min/Max values of respective GNDs).

According to the W3 and W6 indexes, Miyanadeniya GND (e.g. values 0.6, 0.37 respectively) observed as most vulnerable regional admin units. ESAC index also highlighted Miyanadeniya as the most vulnerable GND (with the value of 0.47). More importantly, Ihalagama and Galukagama GNDs viewed with quite lesser vulnerability values compared to the rest of GNDs, according to all the indexes. In accordance with the balance weighting (W1) and ESAC indexes, Ihalagama can be identified as the least vulnerable GND (with values of 0.26 and 0.21 respectively) in Kuruwita DSD. In particular, socio-economic network and social capital based index represents quite low vulnerability values (ranges from 0.24 to 0.36 on average) compared to the rest of indexes. This may because the socio-economic ties, their reciprocal supports and related social capital are very dense in Kuruwita sampled households as discussed in detail in chapter 4. Numerically, there is no much different seen between W1 and ESAC indexes. More importantly, the balance weighting approach (W1) can be recognized as the basic and more realistic form of social vulnerability to flood inundation of households in this study. Some of considerable variations of vulnerability results at household level can also be seen. Table 6.2 shows very crucial results of the 'top ten least vulnerable' and the 'top ten most vulnerable' households in accordance with each vulnerability index of Kuruwita sampled GNDs. The most important notion behind the figures of table 6.2 is that they illustrate the variability of household's vulnerability according to different indexes.

Table 6.2: The most vulnerable and least vulnerable households (top ten for each) according to different indexes / Kuruwita DSD.

Serial No	W1		W2		W3		W4		W5		W6		ESAC	
	HH no*	Value	HH no	Value	HH no	Value	HH no	Value	HH no	Value	HH no	Value	HH no	Value
1	114	0.010	6	0.014	61	0.021	5	0.021	111	0.011	6	0.014	77	0.010
2	6	0.021	79	0.025	112	0.030	61	0.045	106	0.014	40	0.018	84	0.012
3	77	0.034	41	0.026	92	0.057	6	0.049	102	0.036	89	0.030	79	0.012
4	79	0.037	114	0.028	114	0.079	7	0.052	99	0.057	7	0.038	92	0.014
5	61	0.040	111	0.058	98	0.086	79	0.062	98	0.060	114	0.049	98	0.017
6	111	0.041	61	0.078	113	0.088	80	0.146	78	0.081	62	0.068	78	0.018
7	98	0.055	7	0.099	77	0.127	41	0.160	77	0.108	45	0.082	111	0.023
8	113	0.077	84	0.102	6	0.133	113	0.172	103	0.111	111	0.084	113	0.026
9	106	0.080	77	0.105	84	0.147	110	0.174	105	0.123	30	0.106	114	0.034
10	78	0.118	98	0.125	110	0.178	114	0.178	84	0.145	75	0.112	112	0.042
10	56	0.646	65	0.692	33	0.703	96	0.750	16	0.748	109	0.585	8	0.596
9	35	0.656	97	0.715	34	0.707	35	0.751	55	0.758	65	0.587	4	0.603
8	39	0.660	3	0.719	51	0.710	70	0.756	48	0.784	43	0.617	38	0.605
7	68	0.678	66	0.736	35	0.715	72	0.774	51	0.793	36	0.619	70	0.654
6	48	0.735	31	0.770	15	0.748	48	0.778	36	0.799	48	0.632	31	0.679
5	70	0.738	105	0.772	48	0.761	49	0.779	35	0.806	4	0.675	72	0.715
4	72	0.754	56	0.803	36	0.766	109	0.781	66	0.841	16	0.719	48	0.728
3	36	0.767	49	0.818	39	0.841	36	0.841	72	0.906	87	0.887	16	0.775
2	16	0.868	72	0.886	49	0.914	51	0.843	68	0.935	50	0.921	49	0.809
1	49	0.875	68	0.930	16	0.986	16	0.989	70	0.956	49	0.998	36	0.811

*Notes: W1- Balance; W2 - Socio-demographic based; W3- Physical based; W4- Financial based; W5 - Health based; W6 - Networks and social capital based. * HH no- this number assigned by myself for each household for easing data collection, manipulation & management ; HH numbers and their GNDs-* Ovitigama (1-16), Pahalagama (17-24), Theppanawa (25-33), Miyanadeniya (34-51), Pahala Kuruwita (52-62), Kitulpe (63-72), Ihalagama (73-88), Galukagama (89-114).

Table 6.2 depicts that the social vulnerability to flood inundation of Kuruwita sampled GNDs has ranged from 0.01 to 0.998, according to all the indexes. More importantly, minimum and maximum vulnerability values of W1 and ESAC indicated 0.01 (HH no 114), 0.875 (HH no 49) and 0.01 (HH no 77), 0.811 (HH no 36) respectively. Vulnerability values of both indexes represent quite similar patterns compared to the rest of indexes. For instance, the maximum vulnerability values of the rest of indexes revealed greater than 0.9 and the minimum also revealed > 0.011. The most important notion behind that information is that which households are included into the most and least vulnerable categories. Essentially, this is solely depending on the conditions /representations of all the variables (n=31) in which considered for vulnerability calculation related to each and every household. For example, some of households which experienced even lesser flood inundation depth can also be represented as vulnerable households due to the condition /worseness of other variables. When considering the least/less vulnerable households, some of them have appeared frequently under many indexes, but with considerable variations. For example, household numbers such as 6, 77, 98, 111, and 114 etc. Some of households (e.g. 77, 79, 98, 111) have reported in both W1 and ESAC indexes and some of similar narratives can be seen in other indexes as well. Among the most vulnerable households, some of them have appeared under different indexes with some of variations. For instance, HH no 49 has appeared in six indexes as one of the most vulnerable households while 36, 48, and 72 also are reported under many indexes. It implies that those households are more vulnerable according to considered all the variables. More importantly, six out of seven most vulnerable households (e.g. 16, 36, 48, 49, 70, 72) are appeared in both W1 and ESAC indexes at different vulnerability magnitudes /values. Another salient thing revealed is that some of households which included in both less and most vulnerable categories are belonged to the same GNDs. By contrast, it implies that the condition of each construct/ variable in which related to each GND and their variations within the same geographical setting.

Table 6.3 illustrates the classification of households by vulnerability classes based on two indexes. Household level social vulnerability to flood inundation is classified into five vulnerability classes based upon Jenks algorithm (e.g. Jenks, 1977) as it helps to represent data distribution with natural groups and also helps to minimize the variance within classes and while maximizing the variance between classes. According to the revealed results, around 90% households of Kuruwita sampled GNDs are categorized under the very low, low and moderate vulnerability classes related to both W1 and ESAC indexes. Around 58% and 63% households represent very low or low vulnerability, related to W1 and ESAC indexes respectively while 31% and 29% depict moderate vulnerability.

Table 6.3: Overall vulnerability of GNDs based on W1 and ESAC indexes/ Kuruwita sampled GNDs.

GNDs / vulnerability categories	W1: # of HH by vulnerability classes					ESAC: # of HH by vulnerability classes				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
1. Kitulpe	0	3	3	4	0	0	4	4	2	0
2. Ihalagama	6	8	2	0	0	9	5	2	0	0
3.Galukagama	7	9	10	0	0	14	8	4	0	0
4.Theppanawa	0	7	2	0	0	0	3	5	1	0
5. Pahala Kuruwita	3	6	1	1	0	6	4	1	0	0
6. Miyanadeniya	1	6	4	6	1	1	5	8	2	2
7. Pahalagama	0	5	3	0	0	0	7	1	0	0
8. Ovitigama	3	2	10	0	1	1	5	8	2	0
Total households (%)	20 (18)	46 (40)	35 (31)	11 (10)	2 (2)	31 (27)	41 (36)	33 (29)	7 (6)	2 (2)

*Notes: Vulnerability Classes: **1**= Very low (<0.2), **2**= Low (>=0.2 - <0.4), **3**=Moderate (>=0.4 - <0.6), **4**= High (>=0.6 – <0.8), **5**=Very High (>= 0.8).*

Moreover, regarding the high and very high vulnerability categories, almost little percentages can be seen, for example, 11%, 2% and 7%, 2% households are identified respectively related to W1 and ESAC indexes. And also, similar narratives are depicted among sampled GNDs as well. Foremost reason behind these vulnerability patterns is may be the significant influence of socio-economic networks and related social capital metaphors on the reduction of flood inundation vulnerability. On the other hand, some of different vulnerability patterns also seen in the rest of vulnerability indexes (e.g. tables 6.1, 6.2).

Figure 6.1 shows that the scatter plot graphs of correlations between MFCSVIs and ESAC vulnerability indexes in Kuruwita sampled households. More importantly, high positive correlation shows between W1 and ESAC indexes (R square is 0.818) compared to the rest of pairs. Another important notion implies by figure 6.1 is that the balance weighting (W1) and IPCC vulnerability framework based approach (ESAC) can be considered as the actual or existing vulnerability conditions of sampled households. And also, quite similar narratives are exemplified by the table 6.2.

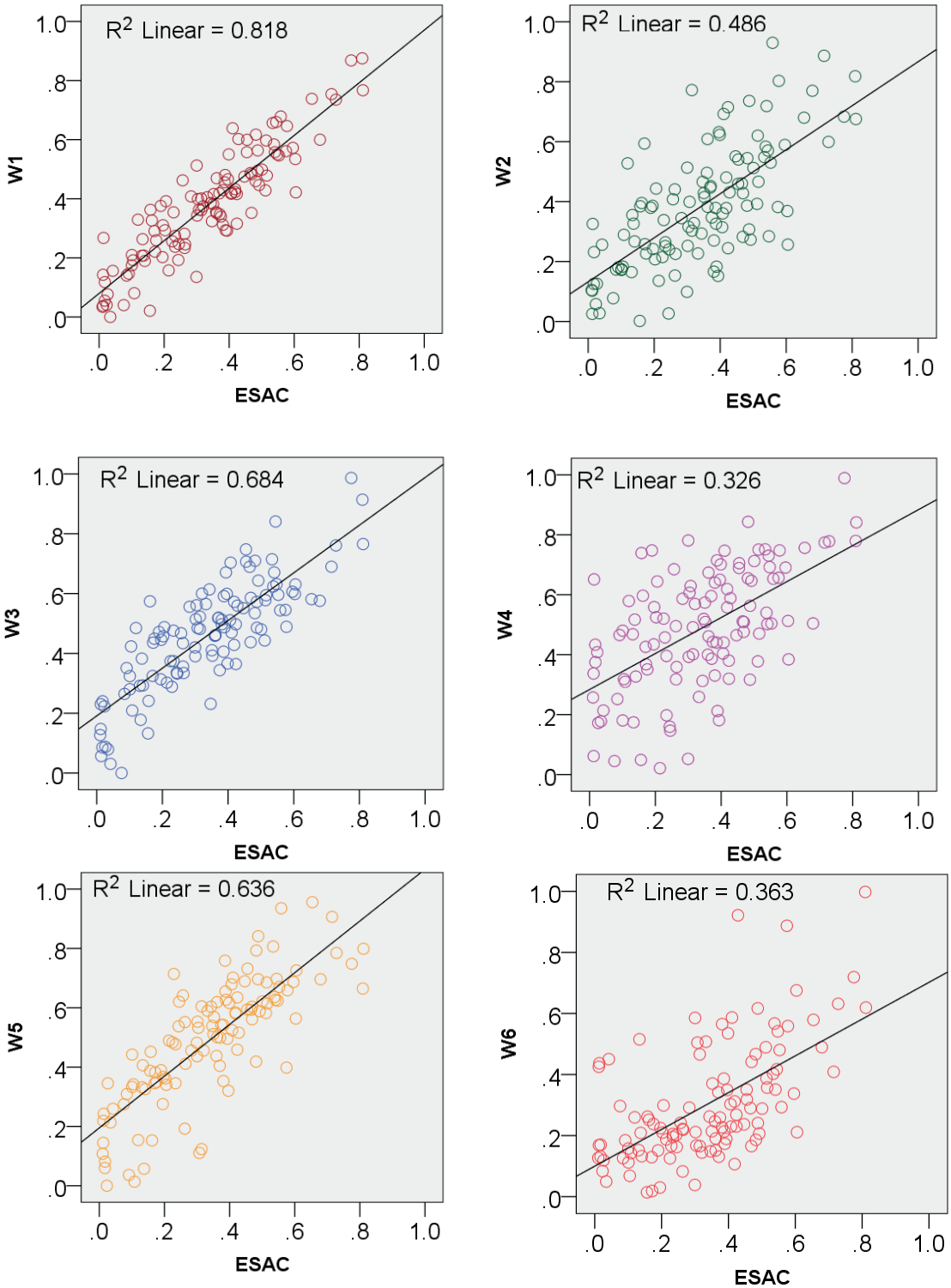

Figure 6.1: Comparison of correlations between different vulnerability indexes with IPCC vulnerability framework based ESAC index (n= 114 households) / Kuruwita DSD.

More importantly, different GNDs are vulnerable under different indexes, in accordance with the condition of their variables. Overall, none of outliers were found in the considered observation units (n=114) of Kuruwita DSD. By contrast, almost similar linear associations are observed between both vulnerability indexes in Kuruwita sampled households. Therefore, the Multi Facets Composite Social Vulnerability Index (MFCSVI) which is tested by this study can be considered as a sophisticated vulnerability index that could be used for the calculation of vulnerability of rural flood inundated areas. By contrast, it also can be recognized as the improved version of ESAC. Nevertheless, theoretically both the indexes have some of differences as well. On the other hand, social vulnerability indexes couldn't be universal and they may represent almost geographically variegated socio-ecological settings. Therefore, they are very often place-specific and need to be changed in accordance with the regional socio-ecological settings.

6.1.2. Social vulnerability to the flood inundation - Elapatha DSD

The dozens of households were surveyed in Elapatha DSD, compared to the rest of two DSDs in this study. The 213 sampled households were considered for the vulnerability analysis in which belonged to seven GNDs. Table 6.4 shows the vulnerability of all the sampled GNDs of Elapatha under the different indexes. The GND level vulnerability scores were obtained by averaging the vulnerability values of all the relevant households.

Table 6.4: Vulnerability of Elapatha sampled GNDs according to different indexes

GNDs	Vulnerability Indexes/scores						
	W1	W2	W3	W4	W5	W6	ESAC
9. Raddella	0.59 (0.295/0.996)	0.48 (0.175/0.992)	0.68 (0.354/0.999)	0.62 (0.343/0.831)	0.74 (0.387/0.998)	0.42 (0.239/0.832)	0.60 (0.36/0.981)
10. Haldola	0.52 (0.132/0.786)	0.44 (0.103/0.976)	0.61 (0.195/0.871)	0.56 (0.205/0.836)	0.59 (0.321/0.812)	0.48 (0.136/0.946)	0.52 (0.042/0.736)
11. Karangoda	0.46 (0.113/0.798)	0.37 (0.086/0.777)	0.53 (0.171/0.881)	0.51 (0.103/0.861)	0.54 (0.251/0.860)	0.46 (0.20/0.994)	0.45 (0.061/0.889)
12. Dambuluwana	0.51 (0.162/0.777)	0.44 (0.173/0.948)	0.60 (0.152/0.845)	0.61 (0.340/0.825)	0.60 (0.224/0.767)	0.43 (0.211/0.917)	0.48 (0.091/0.779)
13. Amuwala	0.47 (0.228/0.791)	0.38 (0.149/0.999)	0.51 (0.288/0.756)	0.56 (0.293/0.838)	0.59 (0.290/0.746)	0.44 (0.179/0.941)	0.46 (0.241/0.734)
14. Samangama	0.40 (0.211/0.830)	0.43 (0.147/0.803)	0.29 (0.063/0.674)	0.52 (0.339/0.999)	0.65 (0.529/0.866)	0.28 (0.101/0.720)	0.28 (0.109/0.695)
15. Kahawatta	0.43 (0.169/0.662)	0.42 (0.113/0.888)	0.54 (0.349/0.752)	0.55 (0.357/0.772)	0.44 (0.190/0.756)	0.38 (0.066/0.728)	0.46 (0.151/0.763)
Average	**0.48**	**0.42**	**0.54**	**0.56**	**0.59**	**0.41**	**0.46**

Notes: W1- Balance; W2- Socio-demographic based; W3- Physical based; W4- Financial based; W5- Health based; W6- Networks and social capital based; ESAC- IPCC framework based index. (with Min/Max values of respective GNDs).

According to the results revealed, Raddella can be identified as the most vulnerable GND in Elapatha DSD under the W1 and ESAC indexes (e.g. 0.59 and 0.60 respectively) (table 6.4). And also, Samangama identified as the least vulnerable GND with the figures of W1 (0.40) and ESAC (0.28). According to the physical components, it is very vibrant that Raddella GND is very vulnerable (e.g. W3 also 0.68). This is because, on the one hand, the majority of households with highest inundated depths were reported in Raddella GND. On the other hand, all the sampled households were encircled by floodwaters and the GND had gone isolated with mass flooding event. Similarly, Raddella GND exemplified as the most vulnerable GND under other indexes except the socio-economic networks and social capital based index (table 6.4). Haldola (e.g. 0.52, 0.52) and Dambuluwana (e.g. 0.51, 0.48) also identified as fairly vulnerable GNDs among Elapatha sampled GNDs in accordance with the W1 and ESAC indexes respectively. Along with revealed results, average figures of each index also revealed overall outlook for the vulnerability in different views. For instance, W6 represents the lowest vulnerability value (0.41) with minimum of 0.28 (Samangama) and maximum of 0.48 (Haldola). In contrast, this implies that Samangama GND has dense socio-economic networks and social capital bases in cumulative manner. Nevertheless, regional level variations can be identified with the household level vulnerability figures.

Table 6.5 illustrates that the household level variations of social vulnerability to flood inundation in accordance with the highlighted 20 households. By contrast, least and most vulnerable households' scores and their numbers are depicted in related to the each index. More importantly, the majority of same households are appeared in the each index list with some of variations. For examples, five households (e.g. 161, 204, 224, 230, 233, 243) are listed in both the W1 and ESAC indexes with some deviations and similar narratives can be seen between other indexes as well. And also, it implies that the variations of vulnerability values among different indexes are not very high. This is because the vulnerability values are ranged between 0 and 1. According to W1 index, the least vulnerable household is No 233 with the vulnerability value of 0.113 while it has categorized at 6^{th} least vulnerable household under the ESAC index (value is 0.111). This household has situated in Karangoda GND and socio-economic and physical factors are very safe / strong in terms of social vulnerability. They are very rich and safe from stresses even they have experienced flood inundation. Household 161 (located in Haldola GND) with the vulnerability value of 0.042 is reported as the least vulnerable household according to the ESAC index. The second least vulnerable household is 204 under both the W1 and ESAC indexes with vulnerability values of 0.115 and 0.061 respectively.

Table 6.5: The most vulnerable and least vulnerable households (top ten for each) according to different indexes /Elapatha DSD.

Serial	W1		W2		W3		W4		W5		W6		ESAC	
	HH no*	Value	HH no	Value	HH no	Value	HH no	Value	HH no	Value	HH no	Value	HH no	Value
1	233	0.113	224	0.086	302	0.063	204	0.103	319	0.190	319	0.066	161	0.042
2	204	0.115	233	0.088	317	0.107	224	0.122	327	0.205	302	0.101	204	0.061
3	224	0.117	225	0.101	304	0.115	225	0.186	243	0.224	161	0.136	243	0.091
4	161	0.132	161	0.103	243	0.152	166	0.205	233	0.251	303	0.143	230	0.096
5	230	0.147	323	0.113	230	0.171	233	0.269	230	0.262	326	0.145	316	0.109
6	243	0.162	204	0.119	303	0.177	287	0.293	205	0.290	317	0.155	233	0.111
7	319	0.169	206	0.121	161	0.195	230	0.293	281	0.290	281	0.179	304	0.120
8	206	0.189	303	0.147	307	0.199	206	0.311	242	0.293	316	0.191	224	0.134
9	303	0.211	281	0.149	233	0.203	170	0.315	203	0.298	204	0.200	162	0.138
10	287	0.228	271	0.155	316	0.210	202	0.317	204	0.300	233	0.202	311	0.144
10	229	0.766	217	0.777	165	0.853	154	0.799	147	0.866	197	0.743	160	0.736
9	147	0.771	307	0.786	154	0.869	150	0.811	157	0.880	282	0.758	223	0.759
8	266	0.777	315	0.803	193	0.871	240	0.825	139	0.888	216	0.827	322	0.763
7	217	0.781	119	0.816	216	0.880	132	0.831	151	0.890	159	0.832	147	0.770
6	165	0.786	165	0.836	156	0.881	159	0.831	148	0.901	212	0.902	266	0.779
5	282	0.791	324	0.888	235	0.881	165	0.836	154	0.912	251	0.917	156	0.782
4	216	0.792	266	0.948	140	0.888	282	0.838	119	0.928	214	0.939	235	0.828
3	235	0.798	163	0.976	147	0.908	229	0.847	156	0.952	279	0.941	216	0.870
2	315	0.830	159	0.992	150	0.990	217	0.861	132	0.961	160	0.946	217	0.889
1	159	0.996	282	0.999	159	0.999	315	0.999	159	0.998	235	0.994	159	0.981

*Notes: W1- Balance; W2 - Socio-demographic based; W3- Physical based; W4- Financial based; W5 - Health based; W6 - Networks and social capital based. * HH no- this number assigned by myself for each household for easing data collection, manipulation & management ; HH numbers and their GNDs-* Raddella (115-159), Haldola (160-201), Karangoda (202-239), Dambuluwana (240-266), Amuwala (267-301), Samangama (302-318), Kahawatta (319-327).

MFCSVI weighting indexes have highlighted other households as well. For example, physical component weighting based index identified 302 household as the least vulnerable with the value of 0.063 while household 159 is most vulnerable with the values of 0.999. The 302 household has located quite upper land area, but has experienced flood inundation. Their physical as well as other factors made them very safe from flood disaster stresses. It also observed that almost all the GNDs are exemplified with both less and most vulnerable households. In contrast, the variation of the conditions of vulnerability among households is very high. Of course, the socioe-conomic, physical, health, and social networks and social capital conditions have determined the level of vulnerability of each and every household.

Table 6.6: Overall vulnerability of GNDs based on W1 and ESAC indexes /Elapatha DSD

GNDs / vulnerability categories	W1: # of HH by vulnerability classes					ESAC: # of HH by vulnerability classes				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
9. Raddella	0	4	21	19	1	0	2	19	23	1
10. Haldola	1	8	19	14	0	2	5	23	12	0
11. Karangoda	5	10	13	10	0	8	8	11	8	3
12. Dambuluwana	1	4	14	8	0	2	6	11	8	0
13. Amuwala	0	11	17	7	0	0	12	17	6	0
14. Samangama	0	10	5	1	1	6	8	2	1	0
15. Kahawatta	1	4	2	2	0	0	2	4	3	0
Total households (%)	8 (4)	51 (24)	91 (42)	61 (29)	2 (1)	18 (8)	43 (20)	87 (41)	61 (29)	4 (2)

*Notes: Vulnerability Classes: **1**= Very low (<0.2), **2**= Low (>=0.2 - <0.4), **3**= Moderate (>=0.4 - <0.6), **4**= High (>=0.6 – <0.8), **5**=Very High (>= 0.8)*

On the other hand, household 159 (located in Raddella GND) is depicted as the most vulnerable household under four indexes, for example, W1 (0.996); W3 (0.999); W5 (0.998), and ESAC (0.981). Another most salient thing revealed is that under W1 and ESAC indexes, only three household (e.g. 147, 156, 159) belonged to Raddella GND are comprised in the most top vulnerable household list, even Raddella GND has reported as adversely inundated GND of study. This is because other variables also have rigorously influenced to the calculations of final vulnerability indexes.

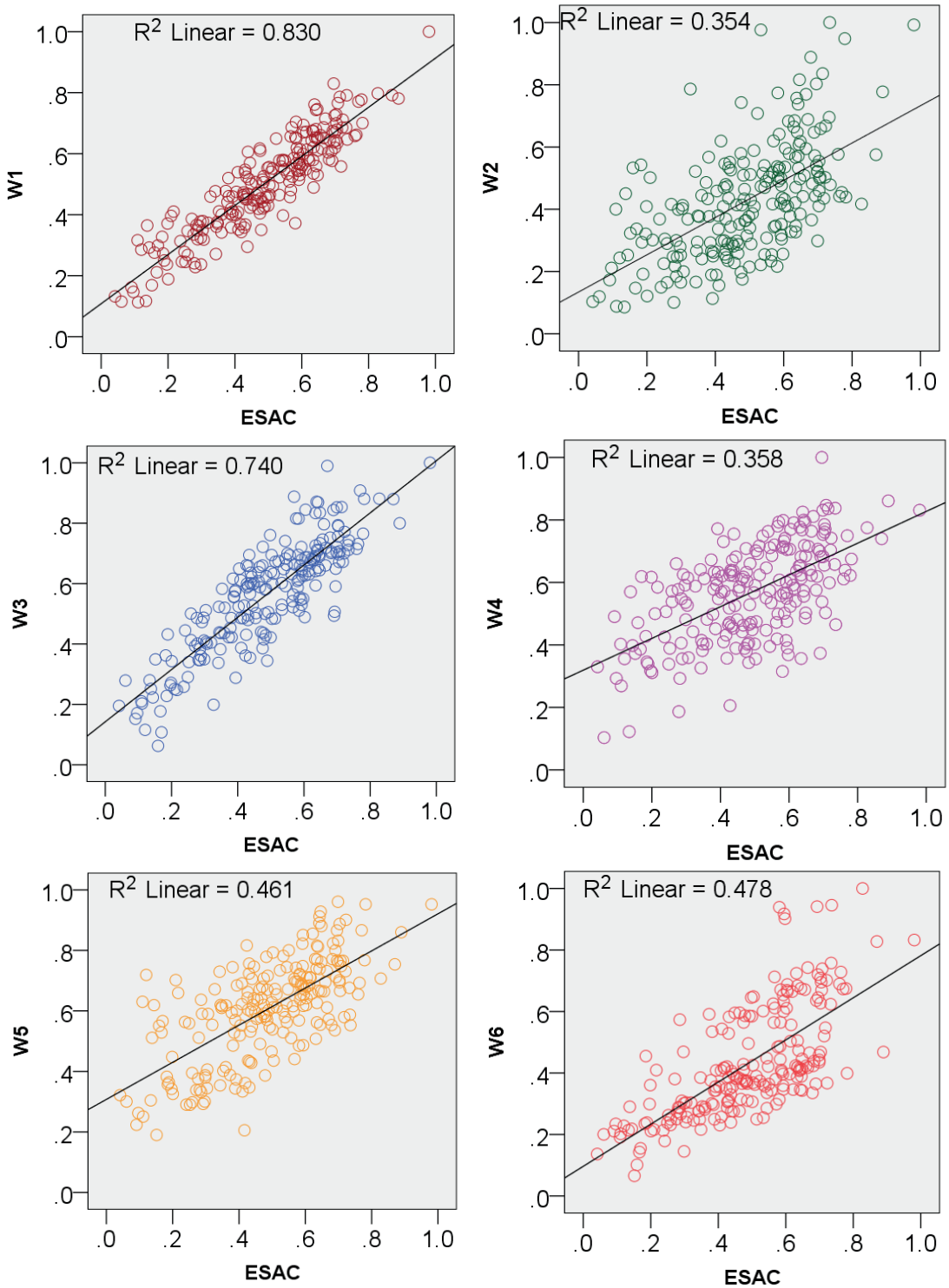

Figure 6.2: Comparison of correlations between different vulnerability indexes with IPCC vulnerability framework based ESAC index (n= 213 households) / Elapatha DSD.

On the contrary, all the top vulnerable households reported under W5 index are belonged to Raddella GND. This is because almost all the health related variables are unsafe in Raddella GND and make people more stresses to flood inundation. Moreover, the influences of considered constructs are varied among regional geographical settings as well. Table 6.6 illustrates the results of vulnerability classification of each household of Elapatha GNDs under W1 and ESAC indexes. It is observed that almost similar narratives can be seen in both the indexes. Altogether very low and low vulnerability categories of both the indexes exemplified with 28% (No 59 and 61 households) households similarly. In the moderate vulnerability category, 42% (91) and 41% (87) households are comprised in the W1 and ESAC indexes respectively. And also, in the high vulnerability category, 61 households (e.g. 29%) indicated similarly in both the indexes. It is also observed that 1 and 2 households as very highly vulnerable according to W1 and ESAC indexes respectively. Moreover, in the GND level, Raddella, Haldola, Karangoda, Dambuluwana, and Amuwala have exemplified with more vulnerable households.

Figure 6.2 illustrates that the association between MFCSVI indexes and ESAC index. More importantly it implies that strong positive correlation between both indexes with the R square of 0.83. By contrast, the MFCSVI can be considered as a suitable social vulnerability index for social vulnerability applications of rural flood inundated areas.

6.1.3. Social vulnerability to the flood inundation -Colombo DSD

All the sampled households (n=78) in Colombo DSD are belonged to informal settlements and they can be identified as slums and shanties. Mostly affected 6 GNDs by past flooding events (mainly 2016 mass flooding event) were selected for the household survey. It is observed that the informal settlements still exist despite even some of informal settlements upgrading and resettlement projects have been undertaking (e.g. Redwood and Wakely, 2012). The majority of informal settlers dislike to relocate into newly built flats despite they have been living in physically unsafe and unconditional housing units. The field observation also confirmed that the majority of households located in Bloumendhal GND were informed to vacate/move out their current households and relocate into newly built flats complex when I carried out household survey. Some of them had already vacated their households and moved in to the newly built flats. However, the rest of residents urged that they are not willing to relocate due to many reasons. But they were warned by authorities that the relocation is enforced /compulsory.

Table 6.7: Vulnerability of Colombo sampled GNDs according to different indexes

GNDs	Vulnerability Indexes / Scores						
	W1	W2	W3	W4	W5	W6	ESAC
16. Bloumendhal	0.54 (0.212/0.815)	0.48 (0.201/0.999)	0.42 (0.202/0.748)	0.48 (0.211/0.764)	0.497 (0.236/0.957)	0.69 (0.204/0.999)	0.38 (0.206/0.609)
17. Madampitiya	0.59 (0.211/0.999)	0.39 (0.201/0.855)	0.66 (0.289/0.922)	0.61 (0.282/0.978)	0.58 (0.212/0.762)	0.59 (0.20/0.999)	0.47 (0.216/0.70)
18. Mahawaththa	0.52 (0.212/0.721)	0.42 (0.209/0.611)	0.57 (0.205/0.848)	0.59 (0.210/0.696)	0.51 (0.309/0.631)	0.44 (0.211/0.880)	0.40 (0.212/0.658)
19. Sa mm anthranapura	0.54 (0.230/0.756)	0.43 (0.202/0.727)	0.47 (0.215/0.715)	0.64 (0.426/0.905)	0.55 (0.467/0.735)	0.53 (0.201/0.905)	0.34 (0.215/0.496)
20. Mattakkuliya	0.45 (0.214/0.729)	0.40 (0.205/0.565)	0.53 (0.214/0.684)	0.63 (0.512/0.777)	0.40 (0.268/0.551)	0.40 (0.203/0.848)	0.31 (0.221/0.372)
21. Modara	0.71 (0.321/0.929)	0.51 (0.210/0.928)	0.76 (0.433/0.999)	0.71 (0.448/0.998)	0.70 (0.566/0.999)	0.64 (0.206/0.940)	0.50 (0.222/0.685)
Average / urban	**0.557**	**0.438**	**0.569**	**0.609**	**0.539**	**0.550**	**0.400**
Average / rural	**0.435**	**0.405**	**0.505**	**0.525**	**0.555**	**0.355**	**0.405**

Notes: W1- Balance; W2- Socio-demographic based; W3- Physical based; W4- Financial based; W5- Health based; W6- Networks and social capital based; ESAC- IPCC framework based index, (with Min/Max values of respective GNDs).

Table 6.7 illustrates that the results of social vulnerability to flood inundation by different indexes for Colombo sampled GNDs. According to the average vulnerability figures of each index, social vulnerability values range from 0.40 (ESAC) to 0.609 (W4). It is observed that Mattakkuliya GND can be identified as the least vulnerable GND in accordance with W1 and ESAC indexes with fairly different values (e.g. 0.445 and 0.310 respectively). And also, Modara GND identified as the most vulnerable GND with referenced to the same indexes (e.g. 0.713 and 0.498 respectively). According to the revealed results (average), all the weighted indexes (W1 – W6) depict quite higher vulnerability figures compared to the ESAC index in Colombo GNDs. This is because, the socio-demographic, physical, financial, health and socio-economic networks and social capital components related to almost all the sampled households in Colombo GNDs are at low or alarming levels. It is examined that in many South Asian flood inundated mega cities; hazards, risk, and vulnerability levels are generally very high (e.g. Dewan, 2013). In particular, mega cities in India and Bangladesh have adversely been affected by flood vulnerability yearly. Many areas in Colombo city (mainly in Thimbirigasyaya DSD) have been experienced flash floods mainly due to torrential rains during the South-West monsoon period. This study mainly considered the areas where inundated due to the river overflows / river flooding in Colombo city.

Tables 6.8 presents the top ten most vulnerable and top ten least vulnerable households of Colombo sampled GNDs according to different indexes. The minimum vulnerability value of all indexes is 0.20 (HH no 401, W1) and the maximum is 0.999 (e.g. HH no 397, W1; HH no 331, W2; HH no 371, W3; HH no 371, W5; HH no 397 and 342, W6). The IPCC vulnerability framework based index (ESAC) depicts fairly low vulnerability values (e.g. a minimum value of 0.206 and a maximum value of 0.70) compared to MFCSVI based indexes. All the top ten vulnerable households in which categorized under ESAC index are belonged to three GNDs, namely Bloumendhal (no 328, 329), Modara (no 371, 373, 376), and Madampitiya (no 386, 397, 399, and 403). More importantly, the top ten vulnerable households related to the W1 index are also belonged to the same GNDs, for example, Bluomendhal (no 329, 341, 342), Modara (no 371, 373, 374, 375, and 376), and Madampitiya (no 397, 403). Therefore, Bluomendhal, Modara, and Madampitiya GNDs can be identified as the most vulnerable GNDs to flood inundation in Colombo DSD. Despite, under the index W6, top ten vulnerable households are belonged to two similar GNDs, namely Bluomendhal (no 329, 337, 341, 342, 352, 354, 359) and Madampitiya (no 397, 399, 403) GNDs. Those ten households can be identified as socio-economic networks and social capital mostly week households compared to the rest of sampled household in Colombo GNDs.

Different vulnerability status are observed under different indexes. For instances, Sammanthranapura (HH no 366, W2; Mahawaththa (HH no 387, W3) Mattakkuliya (HH no 381, W6) etc. More importantly, it is observed that both the top ten vulnerable and top ten low vulnerable households are situated in the same GNDs. It implies that the household vulnerability vary in accordance with the relevant vulnerability variables of each household. It is also observed that the similar households (most and least vulnerable) are being categorized under different indexes with some considerable variations. By contrast, the susceptibility to stresses and social vulnerability from flood inundation is determined by the status of vulnerability variables of households.

Table 6.9 shows the overall vulnerability of households by different vulnerability categories related to each GND in accordance with W1 and ESAC indexes. It is observed that none of households were found under the very low vulnerability category, under both indexes. In accordance with the W1 index, 26% households (n=20) and 31% households (n=24) are found under the low and moderate vulnerability categories while 55% (n=43) and 32 (n=25) indicated under the ESAC index for same categories respectively.

Table 6.8: The most vulnerable and least vulnerable households (top ten for each) according to different indexes /Colombo DSD.

Serial	W1		W2		W3		W4		W5		W6		ESAC	
No	HH no*	Value	HH no	Value	HH no	Value	HH no	Value	HH no	Value	HH no	Value	HH no	Value
1	401	0.211	401	0.201	340	0.202	389	0.210	401	0.212	401	0.200	351	0.206
2	389	0.212	351	0.201	389	0.205	338	0.211	332	0.236	389	0.201	340	0.211
3	340	0.212	364	0.202	349	0.208	340	0.212	335	0.242	364	0.201	389	0.212
4	380	0.214	405	0.204	335	0.211	349	0.213	340	0.253	360	0.202	364	0.215
5	351	0.215	378	0.205	336	0.212	350	0.249	380	0.268	379	0.203	405	0.216
6	360	0.223	389	0.209	344	0.213	328	0.278	334	0.276	356	0.204	348	0.218
7	364	0.230	356	0.210	380	0.214	401	0.282	330	0.304	392	0.204	363	0.219
8	346	0.231	372	0.210	364	0.215	345	0.295	389	0.309	384	0.205	380	0.221
9	356	0.247	367	0.211	331	0.225	348	0.297	378	0.318	357	0.205	372	0.222
10	400	0.275	400	0.212	384	0.238	329	0.308	379	0.322	372	0.206	401	0.222
10	329	0.781	366	0.727	373	0.812	341	0.764	373	0.719	359	0.940	328	0.602
9	341	0.797	339	0.736	393	0.823	374	0.764	369	0.735	354	0.941	329	0.609
8	375	0.809	337	0.738	397	0.837	381	0.777	397	0.745	352	0.943	371	0.622
7	376	0.812	330	0.738	387	0.848	375	0.804	398	0.751	399	0.946	399	0.628
6	374	0.813	329	0.766	395	0.850	373	0.815	391	0.762	337	0.960	373	0.630
5	342	0.815	397	0.855	376	0.908	391	0.832	341	0.769	329	0.963	398	0.646
4	403	0.820	375	0.863	399	0.921	403	0.838	342	0.775	403	0.965	386	0.658
3	371	0.902	373	0.864	398	0.922	366	0.905	338	0.902	341	0.987	376	0.685
2	373	0.929	371	0.928	374	0.949	397	0.978	329	0.957	342	0.999	403	0.688
1	397	0.999	331	0.999	371	0.999	371	0.998	371	0.999	397	0.999	397	0.700

*Notes: W1- Balance; W2 - Socio-demographic based; W3- Physical based; W4- Financial based; W5 - Health based; W6 - Networks and social capital based. * HH no- this number assigned by myself for each household for easing data collection, manipulation & management ; HH numbers and their GNDs- Bloumendhal (328-359), Sammanthranapura (360-369), Modara (370-377), Mattakkuliya (378-383), Mahawaththa (384-389), Madampitiya (390-405).*

Table 6.9: Overall vulnerability of GNDs based on W1 and ESAC indexes / Colombo DSD.

GNDs / vulnerability categories	W1: # of HH by vulnerability classes					ESAC: # of HH by vulnerability classes				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
16. Bloumendhal	0	8	11	12	1	0	18	12	2	0
17. Madampitiya	0	4	4	6	2	0	6	6	4	0
18. Mahawaththa	0	2	1	3	0	0	4	1	1	0
19. Sammanthranapura	0	2	5	3	0	0	7	3	0	0
20. Mattakkuliya	0	3	2	1	0	0	6	0	0	0
21. Modara	0	1	1	1	5	0	2	3	3	0
Total households (%) / urban	0	20 (26)	24 (31)	26 (33)	8 (10)	0	43 (55)	25 (32)	10 (13)	0
*Total households (%) / rural	28 (9)	97 (30)	126 (38)	72 (22)	4 (1)	49 (15)	84 (25)	120 (37)	68 (21)	6 (2)

*Notes: Vulnerability Classes: **1**= Very low (<0.2), **2**= Low (>=0.2 - <0.4), **3**= Moderate (>=0.4 - <0.6), **4**= High (>=0.6 – <0.8), **5**=Very High (>= 0.8); * for the next section*

Regarding the high vulnerability category, 33% households (n=26) and 13% households (n=10) are identified under W1 and ESAC indexes respectively. And also, 10% households (n=8) are belonged to very high vulnerability category for the index W1 while none of households were found for the ESAC index under very high category. It is also observed that the majority of households in GND level are classified under the low, moderate, and high vulnerability categories, but very few for very high vulnerability categories. For example, the majority of households (n=5/8) of Modara GND are belonged to the very high vulnerability category under the W1 index. On the other hand, all the sampled households (n=6) of Mattakkuliya GND are classified under the low vulnerability category relate to the ESAC index. Therefore, Mattakkuliya GND can be identified as the least vulnerable among Colombo sampled GNDs.

It is observed that the considerable association (e.g. with the R square of 0.557) between balance weighting (W1) and IPCC vulnerability framework based (ESAC) indexes, according to the figure 6.3. In other words, some of variations can be found in the vulnerability of observation units (households) between two indexes. In other words, some dispersion can be seen in the household vulnerability values related to both indexes.

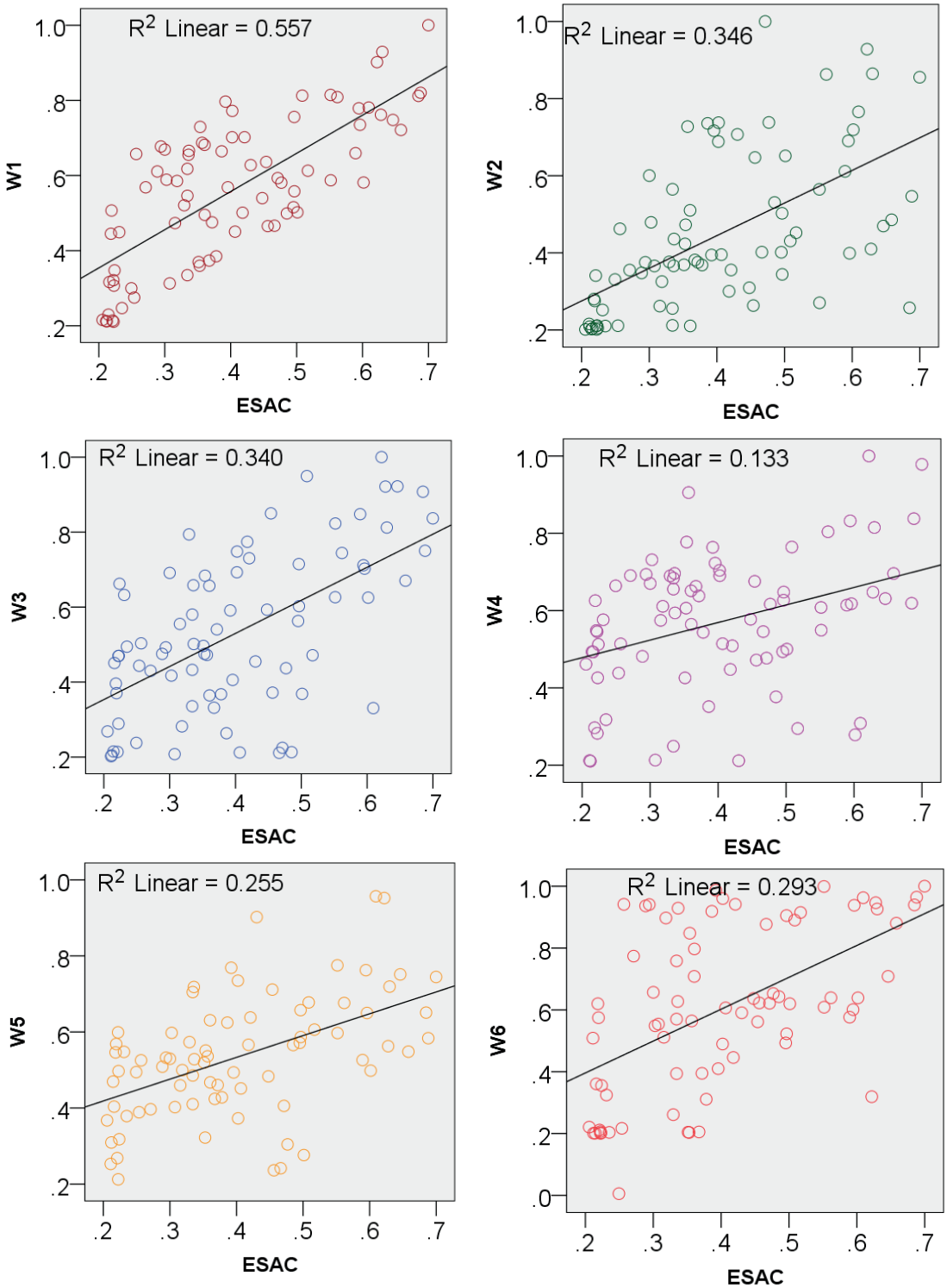

Figure 6.3: Comparison of correlations between different vulnerability indexes with IPCC vulnerability framework based ESAC index (n= 78 households) / Colombo DSD

6.2. Spatial distribution of social vulnerability to the flood inundation

Risk and hazards mapping have been becoming recognized imperative in terms of disaster response and recovery. Similarly mapping of the spatial patterns of social vulnerability to flood inundation helps to determine the areas where adversely vulnerable and less vulnerable to flood inundation by comparing with the rest of areas. It is also very important and crucial mainly for the planning and policy making activities and purposes. In this sense, I tried to apply some of choropleth mapping approaches which help easily to understand the exact spatial patterns and conditions of social vulnerability to flood inundation without any distortion. On the other hand it is quite difficult to apply such advance mapping approaches like dasymetric mapping as it leads to change the basic scores and exact picture of vulnerability. For the household level vulnerability mapping (points), the same classification procedure used in the previous section occupied. For instance, vulnerability categories: 'very low' (< 0.2); 'low' (*>=0.2 - <0.4*); 'moderate' (*>=0.4 - <0.6*); 'high' (*>=0.6 – <0.8*); and 'very high' (*>= 0.8*). For the GND level vulnerability mapping, standard deviation classification method is used, as it indicates how vulnerability differs/varies from the mean.

6.2.1. Spatial patterns of social vulnerability at the household level

I occupied with choropleth mapping to portray the spatial distribution patterns of social vulnerability to flood inundation and their similarities and variations. Figures 6.4 and 6.5 illustrate the spatiality, and spatial variations of social vulnerability to flood inundation of Kuruwita sampled households in accordance with different vulnerability indexes. It is observed that the dark red color points represent the households which are classified under very high vulnerability. According to the figure 6.4, upper left panel (e.g. W1 index), very high vulnerable households can be seen mainly in Miyanadeniya, Ovitigama, and kithulpe GNDs. And also, quite similar patterns are observed in the figure 6.5, bottom left panel (e.g. ESAC index).

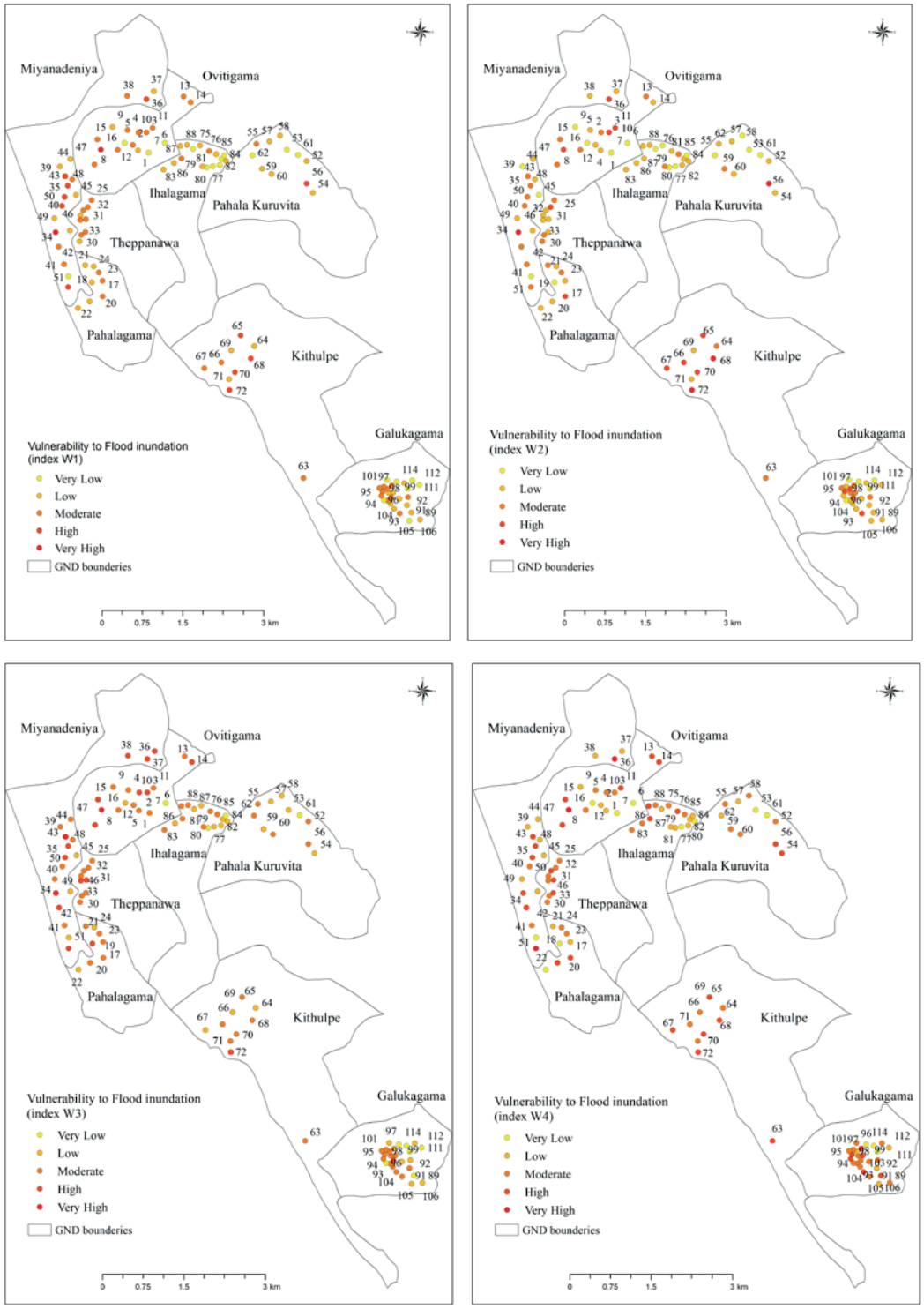

Figure 6.4: Household level distribution of social vulnerability to flood inundation in Kuruwita GNDs. Upper left panel shows W1 index, upper right panel depicts W2 index, bottom left panel presents W3 index, and bottom right panel illustrates W4 index.

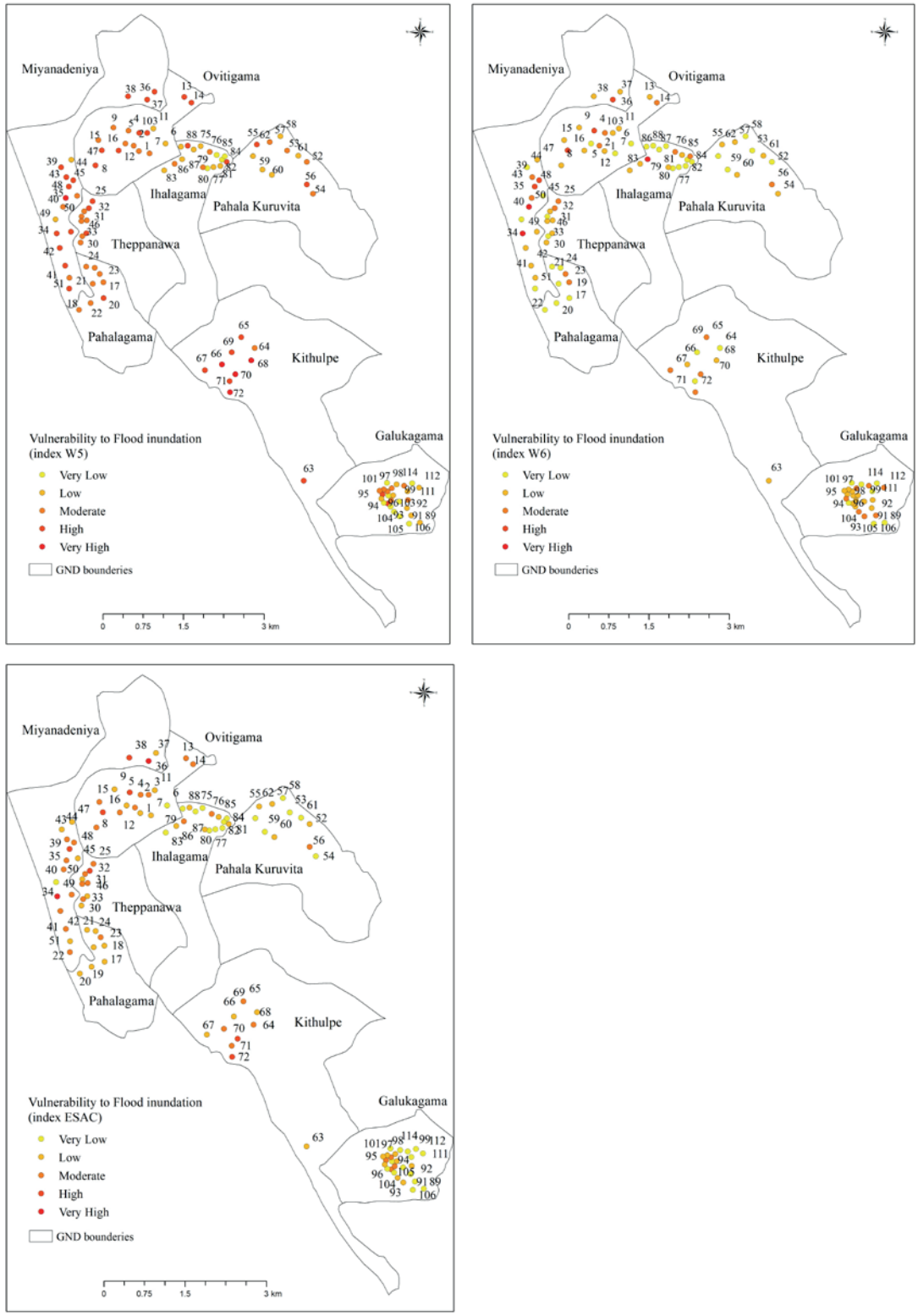

Figure 6.5: Household level social vulnerability to flood inundation in Kuruwita GNDs. Upper left panel shows W5 index, upper right panel depicts W6 index, and bottom left panel presents ESAC index.

According to the balance weighting index (Figure 6.4, upper left panel), the majority of Ihalagama households are observed as less vulnerable. More importantly, many households in almost all the GNDs depict as very high, high, and moderate vulnerability categories under the index W3 (e.g. figure 6.4, bottom-left panel). This is because the conditions of physical vulnerability variables related to many sampled households in Kuruwita GNDs are more adverse. Quite similar patterns can be seen in the households in which related to the index W5 (e.g. figure 6.5, upper left panel). This indicates that the health facility and healthcare conditions of households and their members. It is obvious that households with low healthcare facilities and conditions are more vulnerable for flooding events and those households are more susceptible to many stresses and related perturbations. It is very crucial that some of GNDs such as Ovitigama, Pahalagama, Theppanawa and Miyanadeniya have been encircled by rushing floodwaters during inundation. This is because, the external access and supplies are being blocked and those GNDs almost gone isolated. In these junctures, village level socio-economic networks and their social capital have been instrumental and were the only panacea for healing flood inundation wounds and worries. Therefore, more importantly, the households which are categorized under index W6 (e.g. figure 6.5, upper right panel) show fairly low vulnerability compared to the rest of indexes. And also, it is important to mention that the each and every index has considerable influence form all the vulnerability variables as well. Therefore, even with the situation where having more influences from socio-economic networks to ameliorate social vulnerability to flood inundation, households have categorized under 'more vulnerable' to flood disasters. Nevertheless households have been trained to dealing even with mass flooding events by past flood inundation experiences. All in all, they are living with substantial risks when they are undergoing with higher depth of inundations.

Figures 6.6 and 6.7 illustrate that the spatiality of social vulnerability to flood inundation of Elapatha sampled households (n=213). It is observed that fairly considerable number of households located in Raddella, Dambuluwana, Karangoda and Haldola GNDs are revealed as very high or high vulnerable households (e.g. figures 6.6 and 6.7). This is because the revealed vulnerability results are highly associated mainly with their socio-demographic, physical, financial, and health variables. In particular, almost all the households situated in the village called *GANGA AYINA* in Raddella GND are revealed as high and very high vulnerable households according to their overall conditions. Many of those households have experienced with more than 15 feet flood inundation depth by 2017 mass flooding event and also many of them have located very close proximity to Kalu River.

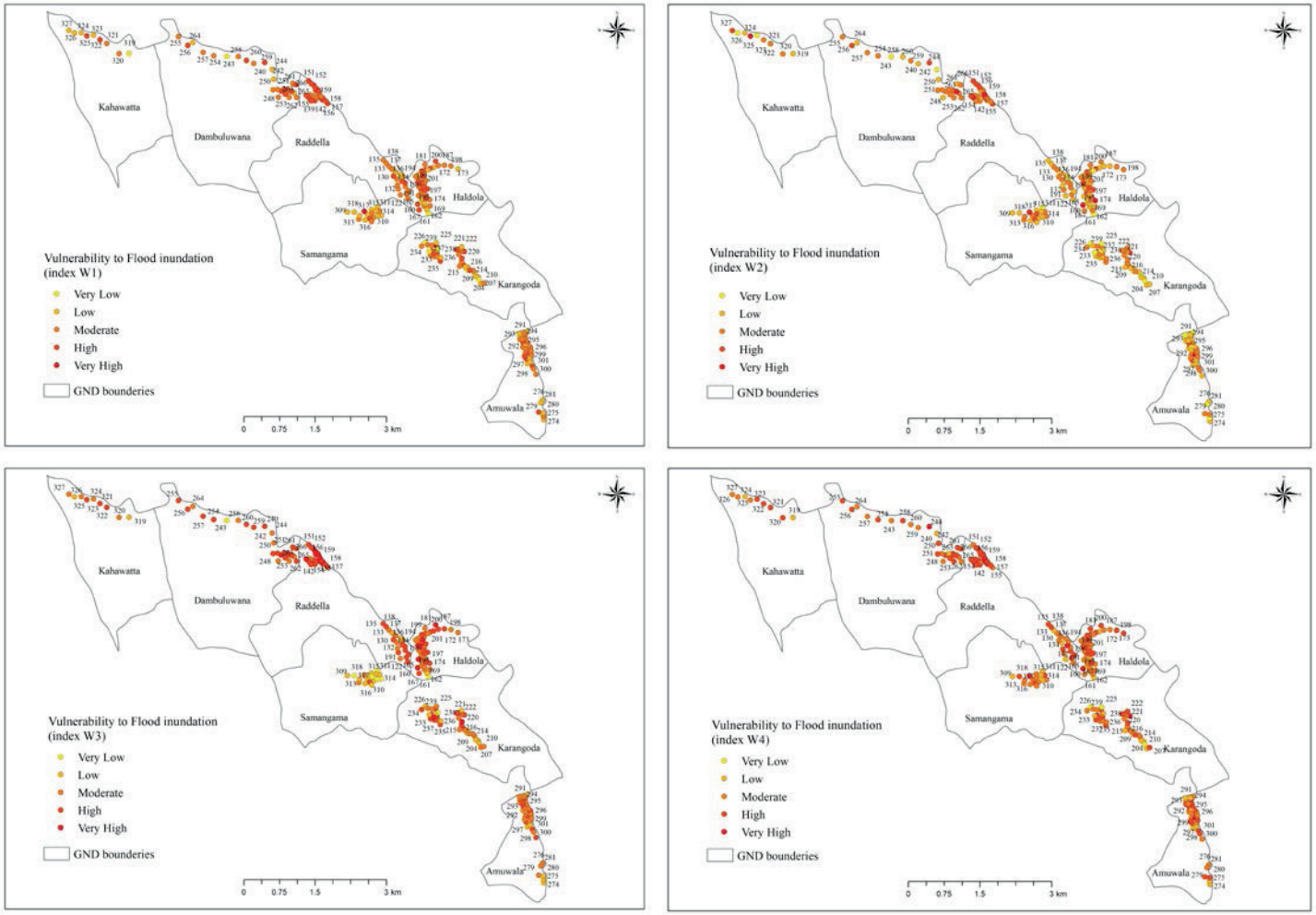

Figure 6.6: Household level social vulnerability to flood inundation in Elapatha GNDs. Upper left panel shows W1 index, upper right panel depicts W2 index, bottom left panel presents W3 index, and bottom right panel illustrates W4 index.

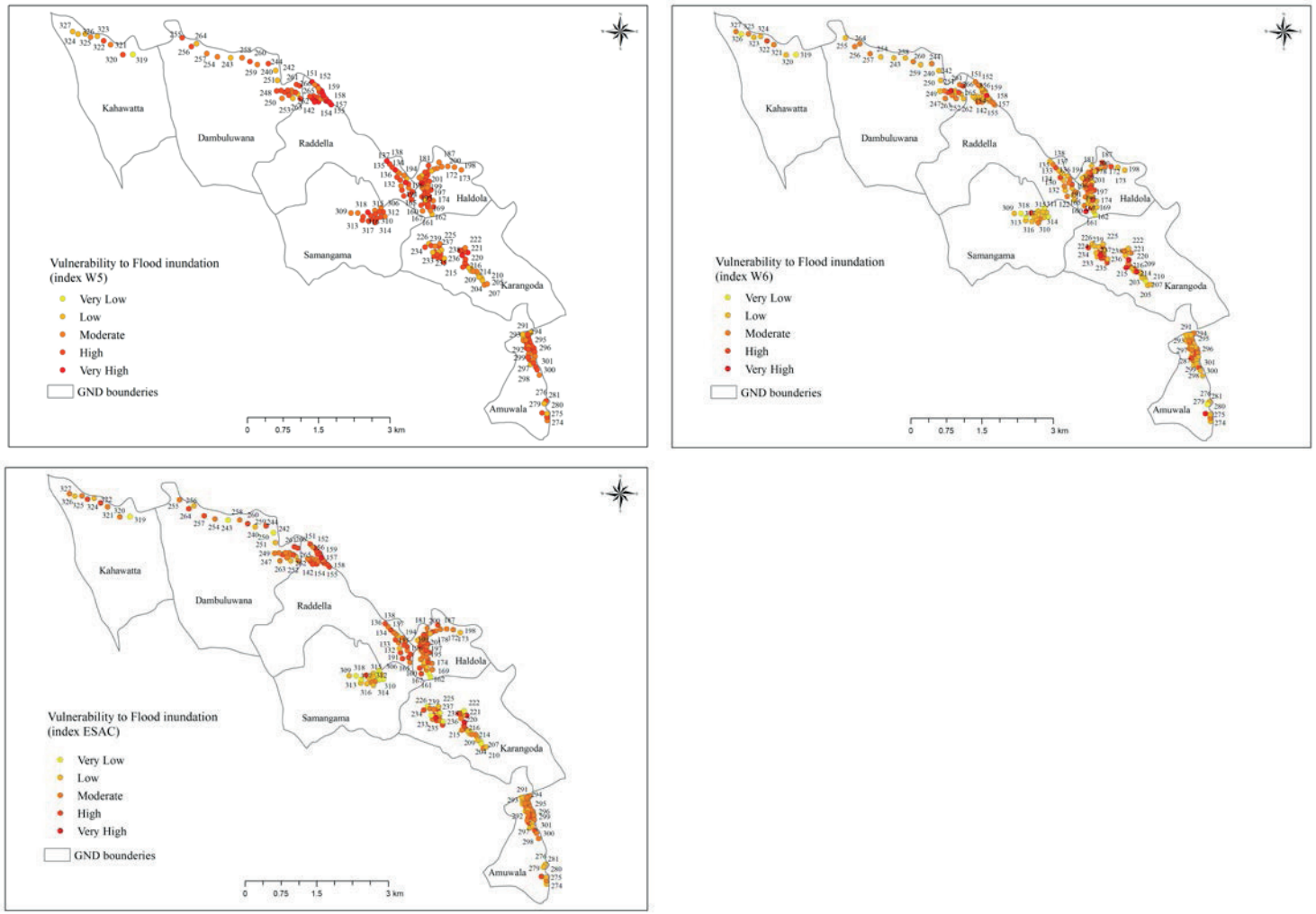

Figure 6.7: Household level social vulnerability to flood inundation in Elapatha GNDs. Upper left panel shows W5 index, upper right panel depicts W6 index, and bottom left panel presents ESAC index.

Many of inundated households that belonged to *DIMIYAWA* village which is also located in Raddella GND, identified as high vulnerable for flood inundation. On the contrary, many of sampled households located in GNDs like Samangama portrayed fairly very low or low vulnerability compared to the rest of GNDs' households in Elapatha DSD (e.g. upper left panel of figure 6.6 and bottom left panel of figure 6.7). Similar narratives can be seen under the physical component' weighted index (W3, figure 6.6, bottom left panel). And also, according to this index, many households situated in Raddella, Dambuluwana, Karangoda, and Haldola are portrayed in dark red or more reddish colors in which implied akin them into more vulnerable group to flood inundation. Inundated households belonged to Kahawatta and Amuwala GNDs also exemplified fairly similar narratives. Households that categorized under the financial component weighted index (W4, bottom right panel of figure 6.6) and health component weighted index (W5, upper left panel of figure 6.7) also present more vulnerable households by the ways in which fairly same results to the W3 index. This is because on the one hand, majority of households are accounted with low financial viabilities and on the other hand they are also accounted with low health facilities and conditions. Similar to the Kuruwita vulnerability results, Elapatha sampled households also show quite low vulnerability level (e.g. lesser amount of reddish color points) under the socio-economic networks and social capital component weighted index (W6, figure 6.7 upper right panel) demonstrating that more strong supports and resources mobilization in the flood inundation events. Overall, Elapatha sampled households exemplified considerably high social vulnerability level to flood inundation in accordance with their backgrounds (vulnerability variables).

Figures 6.8 and 6.9 are showing that the spatial patterns of household level social vulnerability to flood inundation of sampled GNDs in Colombo areas under different indexes. It is important to notice that similar vulnerability classification (five classes) scheme used for Colombo vulnerable household mapping and none of households were observed belonged to 'very low' (< 0.2) vulnerability category due to their inherent low conditions of households and livelihoods. Therefore, all the households of Colombo sampled GNDs are classified under four categories such as low, moderate, high, and very high vulnerability classes using same value ranges for points mapping. According to the almost all the indexes (ESAC index revealed fairly low vulnerability figures), households that are located in Modara, Madampitiya, and Bleomendhal GNDs can be observed as very high or high vulnerable categories. On the other hand, it is observed that under the ESAC index (bottom left panel of figure 6.9), low and very high vulnerability categories were not appeared. It can be postulated that the main reason may be the influenced of 'small size network' measures for the index calculation.

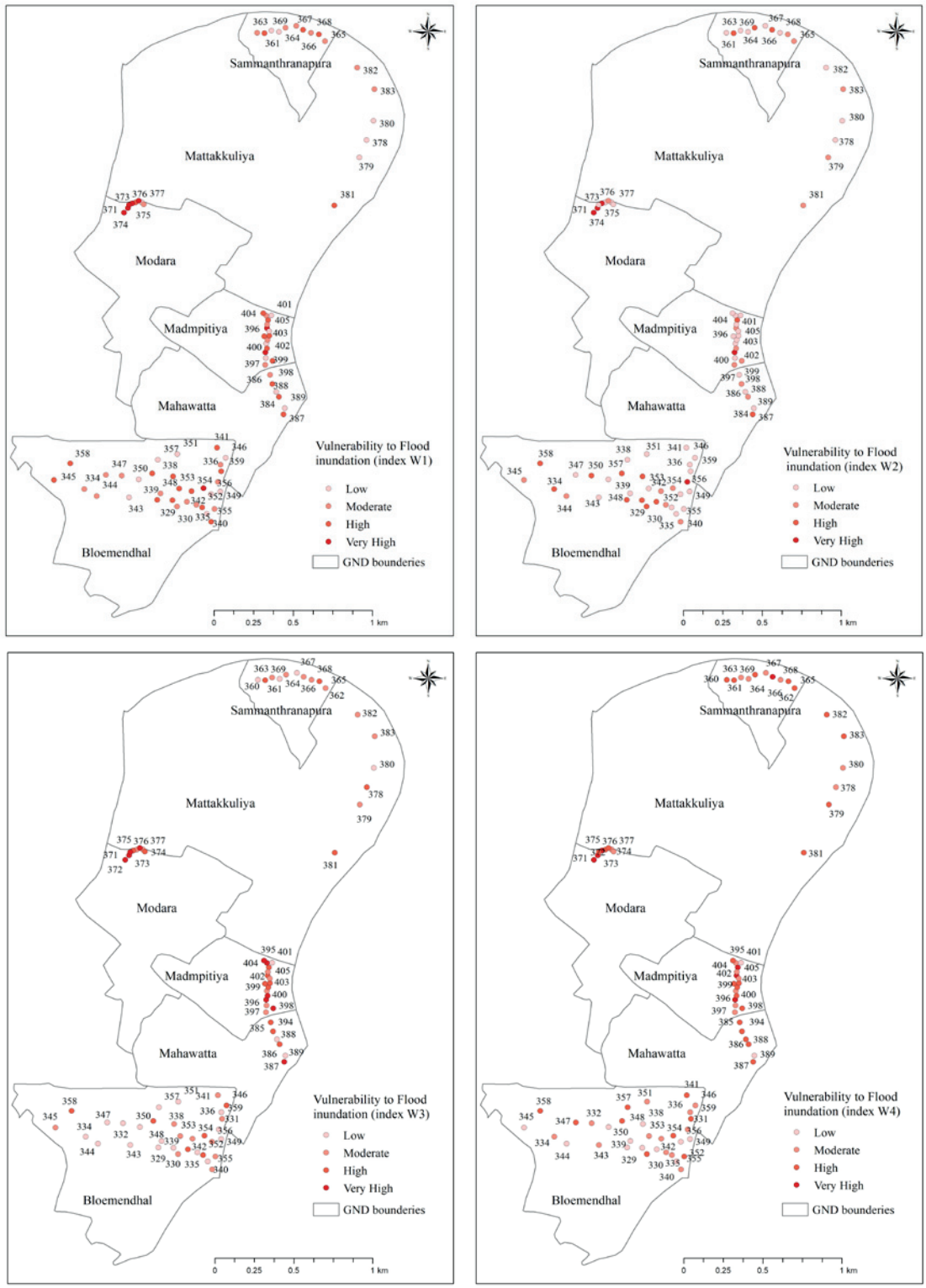

Figure 6.8: Household level social vulnerability to flood inundation in Colombo GNDs. Upper left panel shows W1 index, upper right panel depicts W2 index, bottom left panel presents W3 index, and bottom right panel illustrates W4 index.

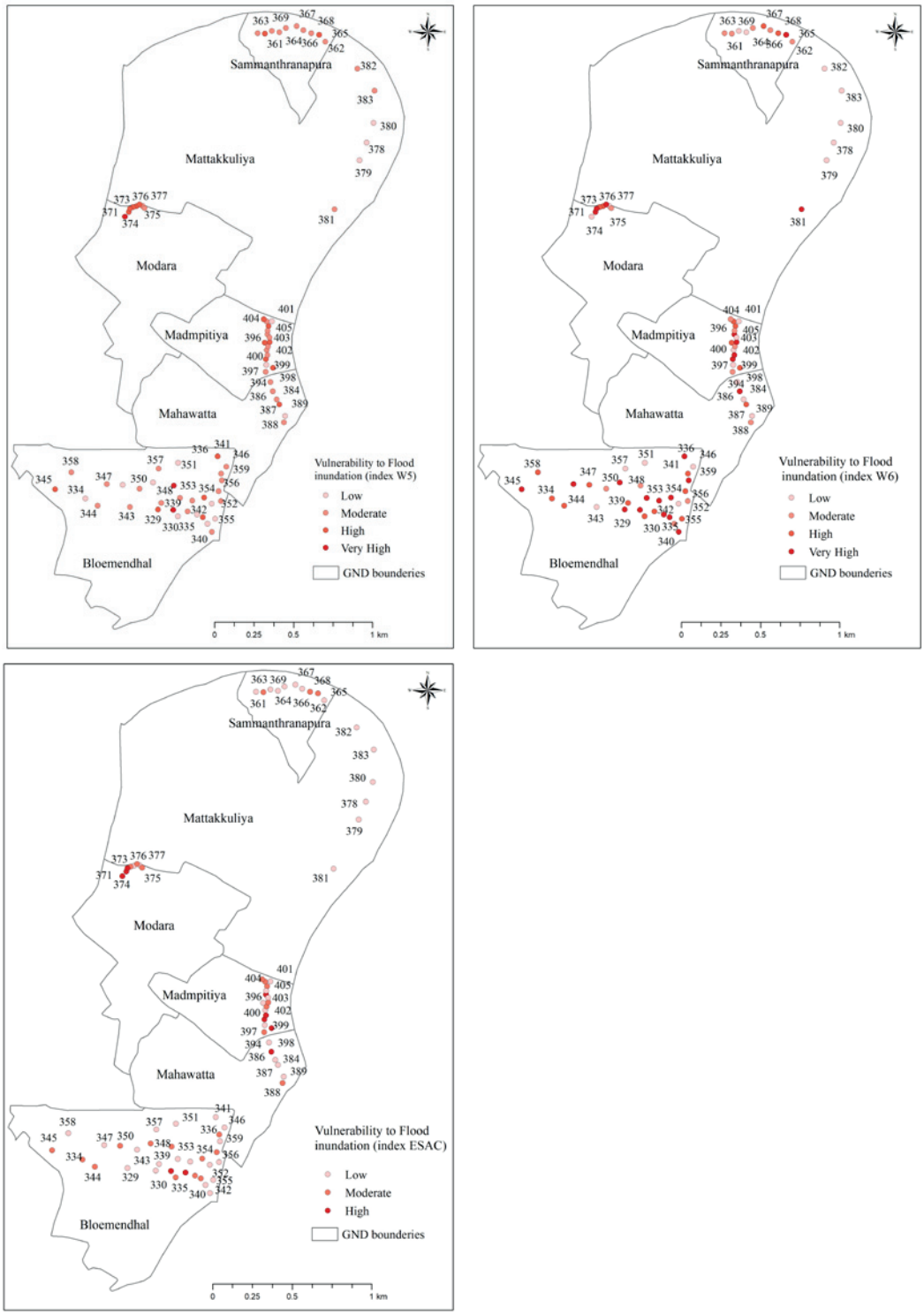

Figure 6.9: Household level social vulnerability to flood inundation in Colombo GNDs. Upper left panel shows W5 index, upper right panel depicts W6 index, and bottom left panel presents ESAC index.

Even though the small size networks are affected for the ESAC index, it may be by very small extent. This is because, for calculation of the fifth vulnerability component, social capital variables also have incorporated with the socio-economic network. And also, W6 index also revealed evidence for abovementioned notion. For instance, considerable number of sampled households in which situated belonging to Bloemendhal, Modara, and Madampitiya GNDs are also shown with the range of moderate to very high vulnerability status. In addition, table 6.9 also illustrates that the exact number of households within which each vulnerability category related to W1 and ESAC indexes in urban areas. It is also observed that many of households situated in Bloemendhal GND are shown as low vulnerable under the W3 index (bottom left panel of figure 6.8). Mattakkuliya sampled households exemplified with fairly low vulnerability under many of indexes. It is important to notice that the social vulnerability to flood inundation and conditions of their variables are fairly worse compared to some of rural areas. Therefore very low vulnerable households were not observed. This is because, urban informal settlements and their households are inherently vulnerable for natural or any kinds of hazards (e.g. Dewan, 2013). Moreover, according to the results, socio-demographic, physical, financial, health and socio-economic network components and related variables are shown to have key causative factors that made greater influenced to the levels of social vulnerability to flood inundation in urban households. Nevertheless, variables such as flood inundation depth and infrastructure facilities etc. are not very much worse in Colombo areas compared to rural context.

6.2.2. Spatial patterns of social vulnerability for the GNDs

As previously mentioned, all the choropleth mapping (Kuruwita, Elapatha and Colombo DSDs) incorporated with standard deviation (Std.) classification method in ArcGIS 10.3.1 environment. It helps to break the classes at above and below the mean value and generates equal value ranges. Values of below and above the mean indicated with – and + marks respectively. By contrast, positive values indicate that high vulnerability (above average) and negative values (below average) indicate low vulnerability. And also, number of classes have generated based on the vulnerability value ranges of each index. It is important to notice that the GND level spatial distribution patterns of social vulnerability to flood inundation is solely depends on the revealed results of sampled households. Figures 6.10 and 6.11 encapsulate that the spatial distribution patterns of social vulnerability to flood inundation in Kuruwita areas by GND level.

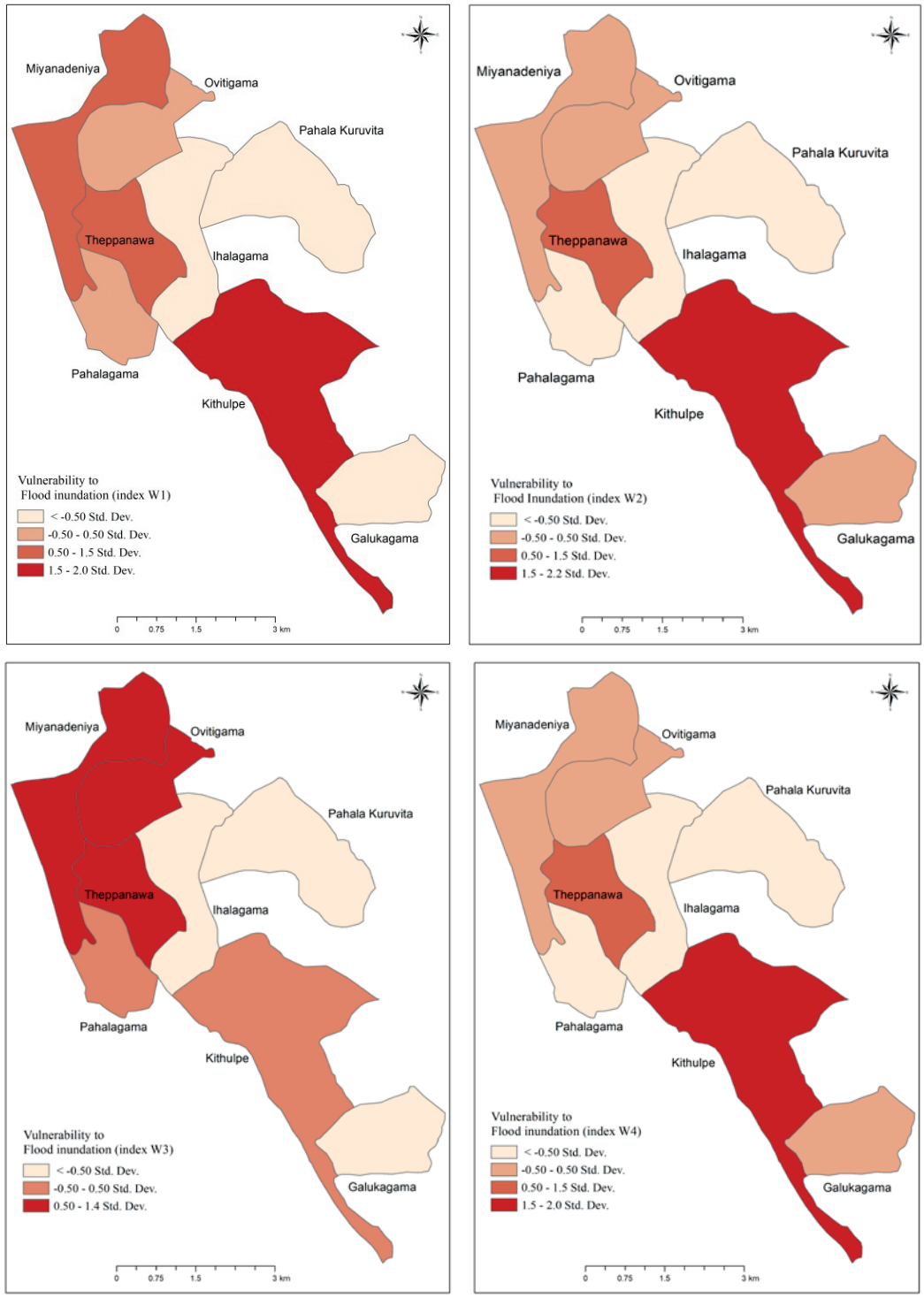

Figure 6.10: Spatial patterns of social vulnerability to flood inundation in Kuruwita GNDs. Upper left panel shows W1 index, upper right panel depicts W2 index, bottom left panel presents W3 index, and bottom right panel illustrates W4 index.

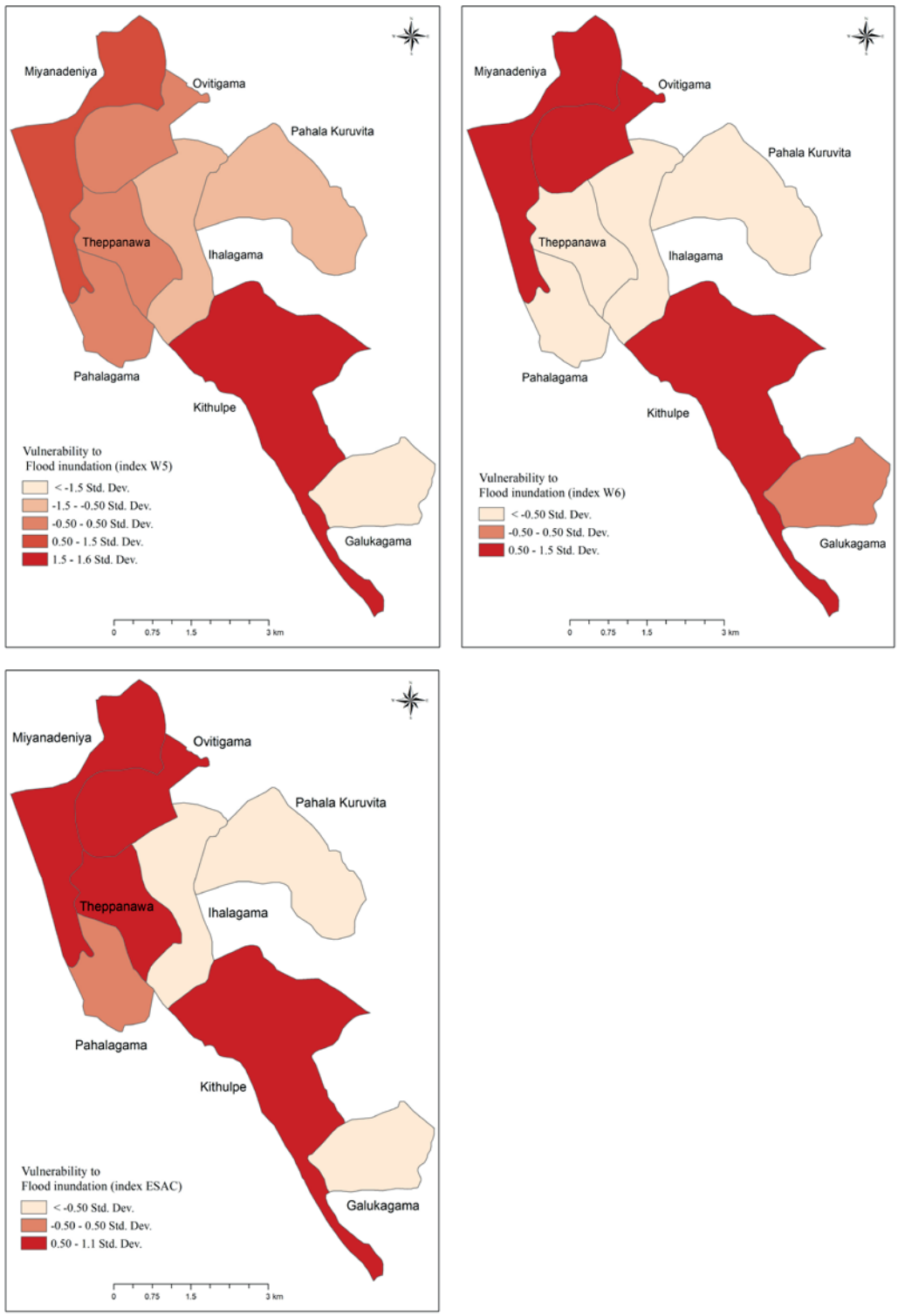

Figure 6.11: Spatial patterns of social vulnerability to flood inundation in Kuruwita GNDs. Upper left panel shows W5 index, upper right panel depicts W6 index, and bottom left panel presents ESAC index.

According to the W1 index results, the vulnerability deviates from Std. -0.5 to +2.0 and Kithulpe identified as more critical GND for vulnerability while Pahala Kuruwita, Ihalagama, and Galukagama observed as low vulnerable GNDs (e.g. upper left panel of figure 6.10). And also, the upper left panel of figure 6.10 illustrates that Ovitigama and Pahalagama observed as between average vulnerability GNDs (e.g. Std. -0.5 - +0.5). The ESAC index shows that Kithulpe, Theppanawa, Ovitigama, and Miyanadeniya GNDs as critical areas (e.g. Std. 0.5 – 1.1) while low vulnerable areas similar to the W1 index (see, bottom left panel of figure 6.11). And also, Pahalagama is as average vulnerable GND among Kuruwita sample areas. More importantly, Kithulpe GND indicated as the critical GND for social vulnerability to flood inundation according to six indexes (except index W3). That result also implies that Kithulpe is not very much critical for physical variables of vulnerability. On the other hand, six indexes (except index W5) have indicated Pahala Kuruwita and Ihalagama GNDs as low critical vulnerable areas for flood inundation. The similar result also denotes that the health related circumstances of Pahala Kuruwita and Ihalagama sampled households may stressful to flood inundation compared to the rest of areas. Financial component weighted index (W4) and socio-demographic component weighted index (W2) revealed almost similar results for all the GNDs (figure 6.10). There is no any kind of empirical vulnerability quantification studies have done earlier, related to these areas for the comparison.

Figures 6.12 and 6.13 show that spatial pattern of social vulnerability to flood inundation in Elapatha GNDs. In accordance with the W1 index, Raddella GND observed as the critical areas for social vulnerability to flood inundation in Elapatha DSD with the Std. 1.5 – 1.8 while Kahawatta and Samangama GNDs as low vulnerable areas with the Std. < -0.5 (upper left panel of figure 6.12). And also, the same index shows Dambuluwana, Karangoda, and Amuwala GNDs as average vulnerable areas with the Std. -0.5 – +0.5. Seemingly this category can be identified as within the moderate vulnerability range. ESAC index revealed fairly different (but not much) results. For example, Raddella GND identified as the critical GND as observed in index W1 while Samangama as the low vulnerable GND. And also, Kahawatta and Dambuluwana GNDs perceive as moderately vulnerable with the Std. -0.5 - +0.5 (bottom left panel of figure 6.13). More significantly, Raddellla GND depicted as the critical GND for flood vulnerability in Elapatha DSD by six indexes (except W6). That result also implies that the socio-economic networks and social capital indicators of Raddella GND is not much bad while Samangama GND exemplified strong socio-economic networks and social capital circumstances with low vulnerability according to the index W6 (upper right panel of figure 6.13).

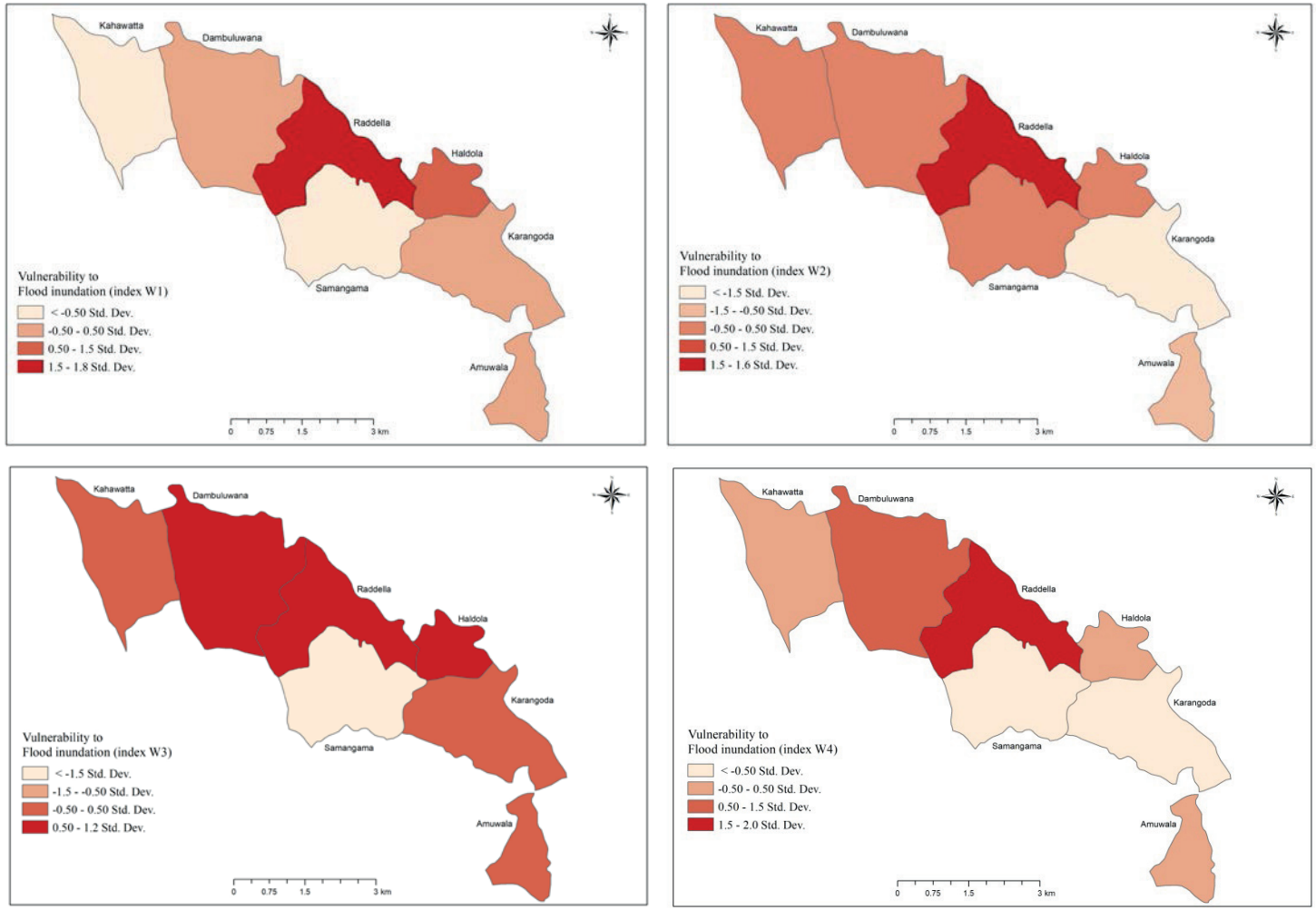

Figure 6.12: Spatial patterns of social vulnerability to flood inundation in Elapatha GNDs. Upper left panel shows W1 index, upper right panel depicts W2 index, bottom left panel presents W3 index, and bottom right panel illustrates W4 index.

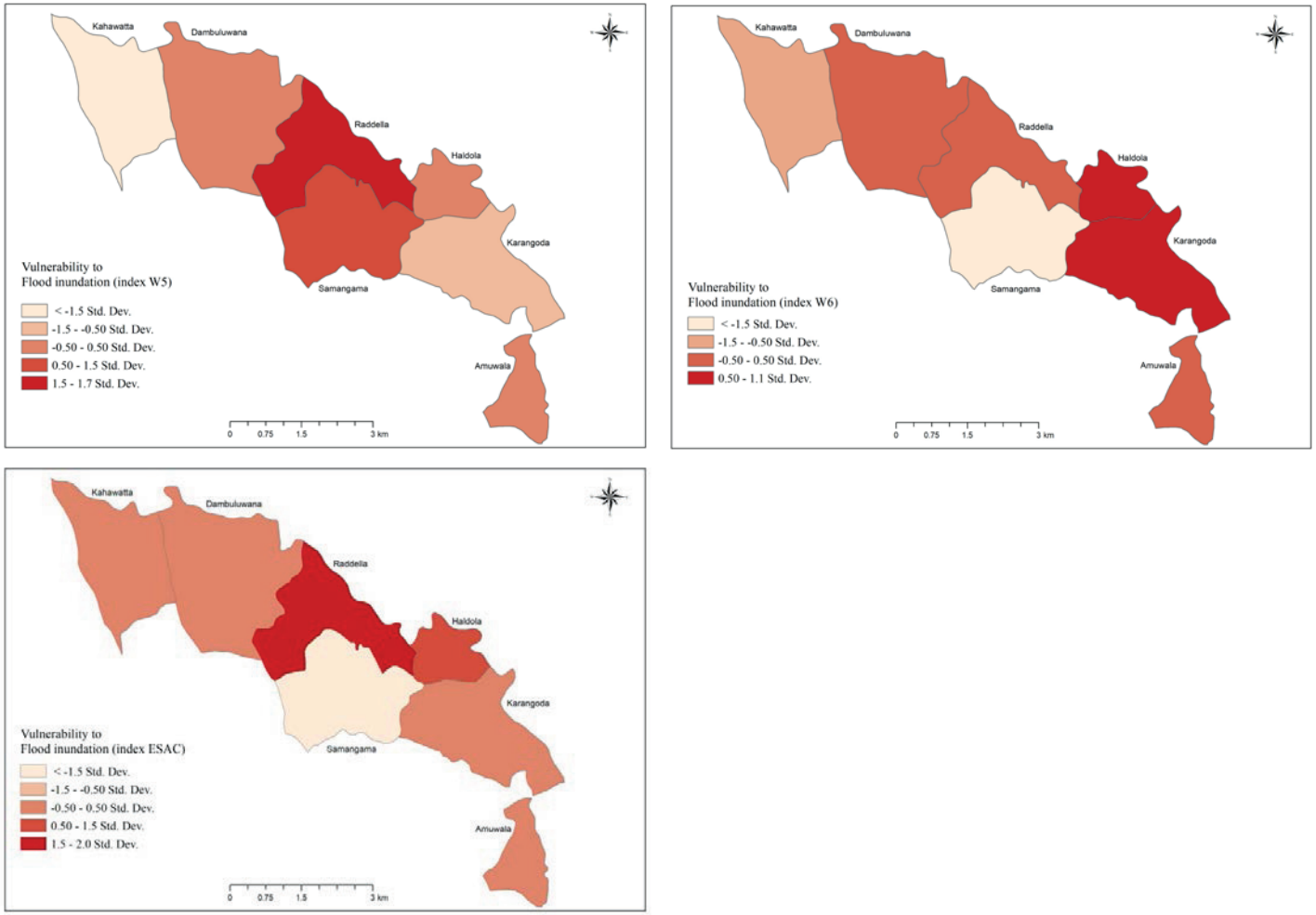

Figure 6.13: Spatial patterns of social vulnerability to flood inundation in Elapatha GNDs. Upper left panel shows W5 index, upper right panel depicts W6 index, and bottom left panel presents ESAC index.

In accordance with the results of W3 index, Raddella, Dambuluwana, and Haldola GNDs perceived as more critical especially in sense of physical variables while Samangama GND as low vulnerable in terms of same variables (bottom left panel of figure 6.12). Moreover, Samangama GND depicted as the low critical area for social vulnerability to flood inundation in Elapatha DSD under five indexes except W2 and W5 indexes as health and socio-demographic indicators fairly week. Elapatha DSD is one of the alarming DSDs in Rathnapura administrative district in SriLanka especially for natural disasters such as frequent floods and landslides. However, no empirical studies were found on vulnerability to flood inundation in order to compare with the results of this study.

Figures 6.14 and 6.15 illustrate that spatial pattern of social vulnerability to flood inundation in Colombo sampled GNDs. According to the revealed results of W1 index, Modara GND identified as the critical area for social vulnerability to flood inundation with Std. 1.5 -1.9 while Mattakkuliya and Mahawatta observed as low vulnerable GNDs with Std. < -0.5. Madampitiya and Bloemendhal GNDs observed as average critical areas with Std. -0.5 - +0.5 according to the same index (upper left panel of figure 6.14). According to the ESAC index, Modara and Madampitiya observed as the critical GNDs with Std. 0.5-1.5 and Mattakkuliya and Sammanthranapura GNDs perceived as low vulnerable area with Std. < -0.5. And also, Mahawatta and Bloemendhal GNDs depicted as the average critical areas for flood vulnerability (Std. -0.5 - +0.5). More importantly, all the indexes revealed that Modara as the most critical GND for social vulnerability to flood inundation among sample GNDs in Colombo DSD. On the other hand, Mattakkuliya observed as the low critical GND under five indexes except W2 and W4. This may because Mattakkuliya exemplified with considerably low financial status and low physical conditions as well. Compared to the Bloemendhal GND the rest of GNDs are observed with low financial circumstances (bottom right panel of figure 6.14). According the World Bank policy research working paper (e.g. Patankar, 2017) has conducted on Colombo flood vulnerability, families with monthly income between 20,001 - 60,000 LKR, identified as the poor households and family with monthly income < 20, 000 LKR identified as below poverty line (BPL). Therefore, in accordance with my study, all the sampled households can be identified as at the BPL. This is because, according to the respondents, the maximum monthly income was 19,000 LKR. This may be very obvious to the informal urban households. However there is a controversy between BPL (Patankar, 2017) and the UNDP (2018) global multidimensional poverty index (MPI). UNDP (2018) identified poor people with their income less than 1.9 $ per day (then average monthly income less than 10,328.43LKR).

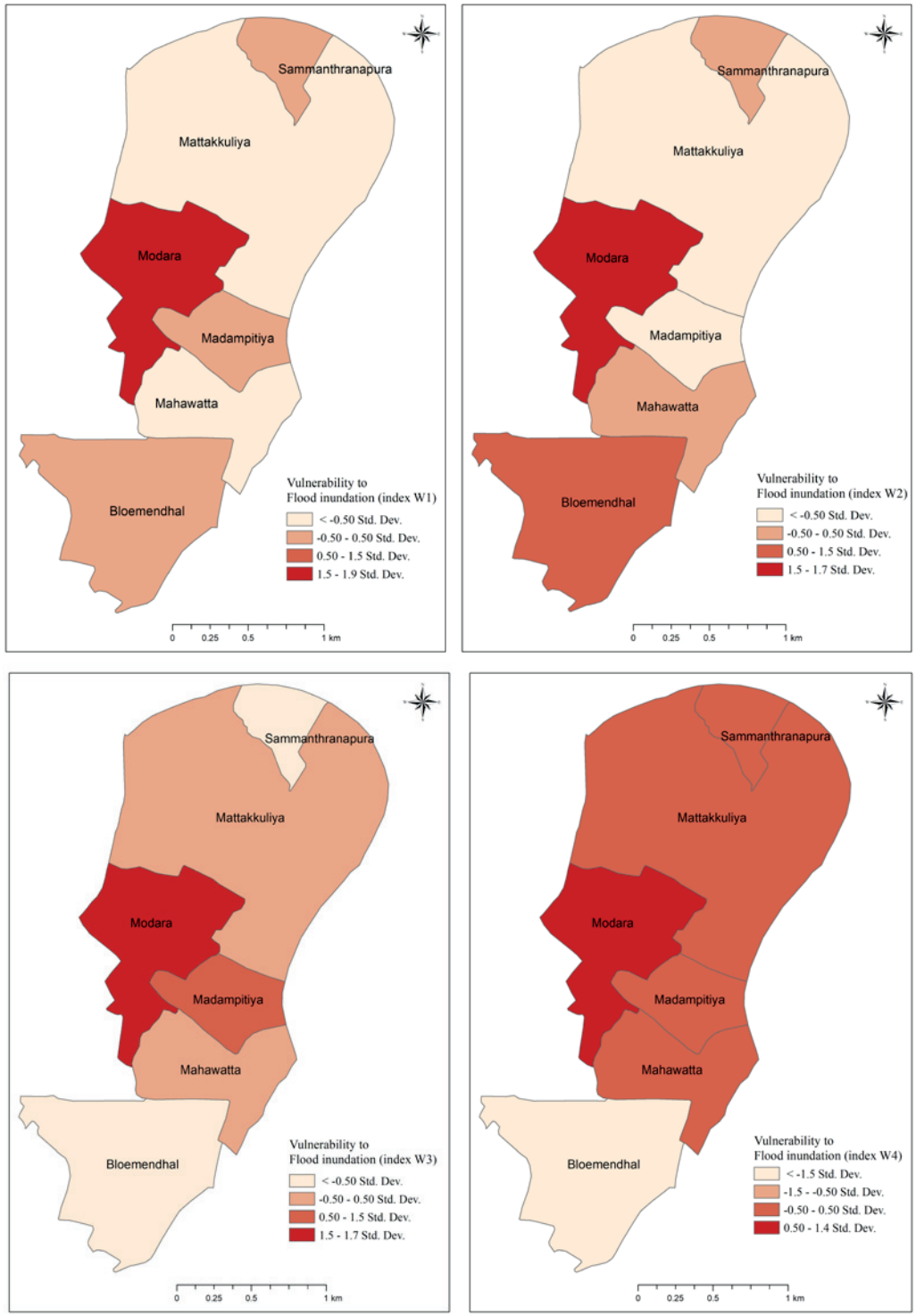

Figure 6.14: Spatial patterns of social vulnerability to flood inundation in Colombo GNDs. Upper left panel shows W1 index, upper right panel depicts W2 index, bottom left panel presents W3 index, and bottom right panel illustrates W4 index.

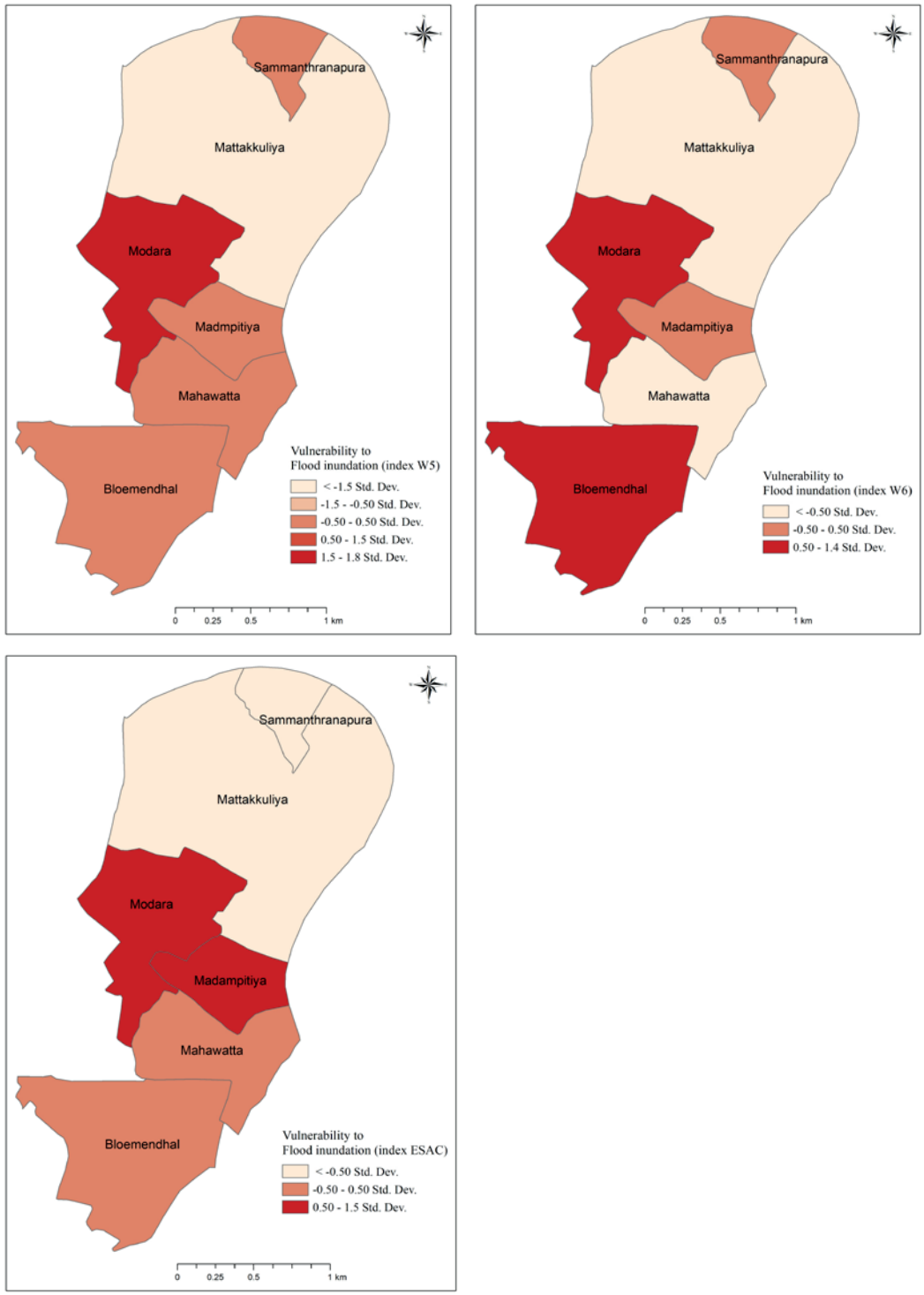

Figure 6.15: Spatial patterns of social vulnerability to flood inundation in Colombo GNDs. Upper left panel shows W5 index, upper right panel depicts W6 index, and bottom left panel presents ESAC index.

All in all, Colombo informal households can be categorized under poor households. Therefore, their vulnerable livelihoods have been experienced more stresses and perturbations from natural disasters (e.g. Edger, 2006) like flood inundation. The city of Colombo as a coastal city is very prone to flood hazards (Patankar, 2017). The similar report revealed that 73% of BPL households have experienced and stressed floods with poor housing conditions and monetary issues as many of them are slums, shanties, and temporary huts. And also that study identified Bloemendhal, Mahawattta, and Modara as mostly flooded areas. However, no vulnerability quantification carried out followed by abovementioned study.

6.3. Geographies of social vulnerability to the flood inundation and rural-urban dichotomy

Vulnerability to natural hazards and its drivers and precursors have been proliferating by many folds due to the augmentation of harmful anthropogenic activities on environment and ecosystems. In particular, almost all the developing countries are being experiencing different kinds of vulnerabilities often may be due to degradation of environment with their livelihood strategies. In contrast, this is mainly due to the (depending on) natural resources. Similarly, the study areas of this study have been experienced accelerated flooding events compared to their past experiences. Therefore, stresses and perturbations to flood hazards and susceptibility to harm from them are intertwined with rural and urban livelihoods. A range of dissimilarities and different narratives on vulnerability to flood inundation are found between rural and urban sectors and also within sectors (e.g. regional disparities).

The MFCSVI indexes provide baseline for the examining the social vulnerability to flood inundation in rural as well as urban areas. More importantly, a range of variations of vulnerability values can be seen between DSDs and sectors as well. According the average vulnerability figures of each GND, Ihalagama GND in Kuruwita DSD represents the minimum average value of index W1 (e.g. 0.26) and Modara GND in Colombo DSD depicts the maximum value (e.g. 0.713) which is belonged to the urban sector. And also, average value of W1 index in Colombo DSD is higher (e.g. 0.56) than the rural DSDs (e.g. Kuruwita 0.39, and Elapatha 0.48) (Tables, 6.1, 6.4, and 6.7). More importantly, the household level minimum value of W1 index is varied among regions and sectors. For example, the minimum value of W1 index is 0.01 (table 6.2) and that household is belonged to Kuruwita DSD while the maximum value indicated from Colombo DSD as 0.999 (table 6.8).

The average vulnerability value of W1 index of rural sector is quite low (e.g.

0.44), compared to the same in urban sector (e.g. 0.56, table 6.7). Fairly similar narratives can be observed with the ESAC index as well. For instance, the average vulnerability values of Kuruwita, Elapatha and Colombo indicated as 0.35, 0.46, and 0.41 respectively with the minimum average value of 0.21 (Ihalagama) and the maximum average value of 0.60 (Raddella). Furthermore, one of households in Kuruwita DSD is attributed with the lowest ESAC value of 0.01 (table 6.2) compared to Elapatha and Colombo ESAC lowest values (e.g. 0.042 and 0.206 respectively, table 6.5 and 6.8). More significantly, it is observed that Kuruwita sampled households illustrate quite lower vulnerability of W1 and ESAC indexes compared to the Elapatha and Colombo sampled households. And also, Elapatha sampled households depict quite higher vulnerability level rather than Kuruwita and Colombo households according to the similar indexes.

Abovementioned scenario implies that the Elapatha sampled households have experienced with the adverse condition of vulnerability causative factors /indicators compared to the rest of DSDs. In particular, regarding the main causative factor of study which is the flood inundation, Elapatha sampled GNDs have experienced the highest inundation depth and the duration of flooding. For example, mainly Raddella, Haldola, Dambuluwana, and Karangoda GNDs, they have experienced average flood inundation depths of 15 feet (min 4, max 23 feet), 13.3 feet (min 4, max 25 feet), 12.5 feet (min 2, max 21 feet), and 11.9 feet (min 2, max 26) respectively according to table 3.9. The average inundation duration also ranges from 6 to 9 days. Due to the coalescence of many causative factors together with flood inundation the livelihoods have adversely been affected by many stresses and perturbations. By contrast, large number of households can be found with the low income levels, low healthcare facilities, and also low levels of socio-demographical factors in Elapatha sampled GNDs. For instance, according to the empirical data, the monthly household income of Elapatha sampled households vary from 4,000 LKR (22.24$ or 0.74$ per day[54]) to 53,000 LKR (294.69$ or 9.8$ per day). The average monthly income of Elapatha sampled households is 19,937.56 LKR (110.4$ or 3.8$ per day). More significantly, 118 households (55.4% of Elapatha sampled households) were found with below the average monthly income of Elapatha sampled GNDs. According to the UNDP (2018), *"the way people experience poverty goes beyond living on less than $1.90 a day"*. And also, the UNDP has considered 10 main variables for the calculation of Global Multidimensional Poverty Index (MPI). Therefore mainly, less income households are possible to be experienced adverse entitlements failures (e.g. Adger, 2006), with a range of shocks and stresses due to flooding events. And also, related to

[54] According to the existing exchange rates

abovementioned households (n=118), considerable number of female headed households (n=23), elderly people (> 65yrs, n=41), children (<5 yrs, n= 36) and 180 female members are observed. On the other hand, these indicators are more decisive as well as pivotal factors for disaster resilience (see, Cutter, *et al.,* 2014). By contrast, the erosion of socio-economic and demographic strengths of households could be leading to adverse effects and vulnerability, especially in the situations of natural disasters like flood inundation. The average monthly income of Kuruwita sampled households is 24,000 LKR (132.86 $, or 4.43$ per day) and it ranges from 6,500 LKR (35.98 $ or 1.2 $ per day) to 63, 000 LKR (348.74$ or 11.6$ per day) (table 3.9). That is fairly higher than Elapatha sampled households.

More importantly, the monthly incomes of 75 households (65.8%) are below the average monthly income of Kuruwita sampled households. In response to those households, 28 children, 27 elderly people, 15 female headed households and 134 female members are reported (table 3.9). Regarding the urban sector, their monthly income is ranges from 3,500 LKR (0.65$ per day) to 19,000 LKR (3.5$ per day) while the average monthly income of sampled households is 10,364.1 LKR (57.35$ or 1.912$ per day). More significantly, it is observed that the monthly incomes of 47 households (60.26%) are below the average income of sampled households of Colombo DSD. Related to abovementioned households, 10 children, 12 elderly people, 10 female headed households, and 44 female members are reported (it is important to notice here that the exact number of family members in each urban informal household is depended on the interviewees' responses). Urban informal households are also can be identified as vulnerable households since they have been experiencing spectrum of stresses from flood inundation and their socio-ecological systems. In contrast, compared to rural households, urban flood vulnerability has augmented by their surrounding circumstances. This is because the flood inundation depths and inundation duration of Colombo sampled households are very low (e.g. maximum 4 feet inundation with two days duration) compared to the rural areas (e.g. Table 3.9). Another important notion observed from revealed results is that the inequality of income and resource distribution mainly among rural areas and households. Urban sampled GNDs also exemplified fairly similar narratives. It indicated by the percentages of households which are below the average monthly income of each DSD. On the one hand, it may leads to the wellbeing related vulnerability (see Edger, 1999) by the ways in which with experiences of flood inundation and on the other hand, that condition could be leads to erode the abilities for absorption of shocks (see, Edger, 2006) from unexpected encounters like flooding events. This situation is may be similar to the absence of resource endowments. In other words, for instance, Cutter and colleagues (2003), vulnerability may adverse with the lacking of access to

resources. The similar narratives can be observed related to the urban informal settlements and their households rather than rural geographical settings more rigorously. Therefore, vulnerabilities to flood inundation in my study also are interdependent scenarios or are complementary in both theoretical and contextual ways.

It is also observed more important aspects in regional contexts related to the rest of vulnerability indexes as well. According to the revealed results, the average values of socio-demographic component weighted index (W2) range from 0.27-0.60, 0.37-0.48, 0.40 -0.51 in Kuruwita, Elapatha, and Colombo DSDs respectively. In contrast, minimum average and maximum average of W2 index observed in Kuruwita DSD. Regional differences (household level) of same index depict that the minimum and maximum as, 0.014/0.95, 0.086/0.999, 0.201/0.999 in Kuruwita, Elapatha, and Colombo households respectively (see, tables, 6.2, 6.5, and 6.8), with rural and urban average scores of 0.41, 0.56 respectively. Socio-demographic status in urban informal households is more vulnerable compared to rural households. Physical component weighted index (W3) indicated with quite high scores for all DSDs and sectors with the highest average score in Elapatha DSD. For example, regarding household level, min/max/average; 0.021/0.986/0.47, 0.063/0.999/0.42, 0.202/0.999/0.41 in Kuruwita, Elapatha, and Colombo DSDs respectively and rural average score was 0.51, compared to urban average score, 0.56. This may because, the conditions of majority of physical variables are week in urban informal settlements compared to rural geographical settings. Nevertheless, some of rural households also found with most week physical status as well. Min/max/average scores of financial component weighted index (W4) depicted as, 0.021/0.989/0.49, 0.103/0.989/0.56, 0.21/0.998/0.61 in Kuruwita, Elapatha and Colombo DSDs respectively with the rural average score of 0.53. Monetary status is very worse in urban informal households as explained in detail earlier in this section. According to the health component weighted index (W5), min/max/average presented as 0.011/0.956/0.52, 0.19/0.998/0.59, 0.212/0.999/0.54 in Kuruwita, Elapatha, and Colombo DSDs with fairly high average score of rural sector 0.56. Because of, some of rural areas situated far away from health facilities and many of rural households reported elderly people with illness. Some rural observations are indicated convolution of health issues with flood inundation. Socio-economic networks and social capital component weighted index (W6), depicted rural and urban average scores as 0.36 and 0.55 respectively. And also, the min/max/average scores observed as 0.014/0.998/0.30, 0.066/0.994/0.41, 0.2/0.999/0.55 in Kuruwita, Elapatha, and Colombo DSDs. More significantly, this result implies that socio-economic networks and social capital legacies in rural areas are very strong compared to the urban context.

Table 6.10: Statistical significant of the difference of W1 and ESAC indexes (the results of pared-samples t – test)

GNDs / test statistics	Mean W1	Mean ESAC	Sd. W1	Sd. ESAC	*t*	df	*P value*	*Correlation*
1.Kitulpe	0.541	0.453	0.162	0.159	2.71	9	0.024 *	0.792
2.Ihalagama	0.26	0.211	0.148	0.175	3.12	15	0.007 *	0.938
3.Galukagama	0.295	0.215	0.162	0.155	5.33	25	0.000 *	0.886
4.Theppanawa	0.453	0.452	0.078	0.106	0.08	8	0.936	0.908
5.Pahala Kuruwita	0.298	0.227	0.161	0.152	3.73	10	0.004 *	0.918
6.Miyanadeniya	0.49	0.467	0.209	0.187	1.02	17	0.321	0.886
7.Pahalagama	0.361	0.336	0.093	0.081	1.02	7	0.343	0.70
8.Owitigama	0.441	0.458	0.208	0.159	-0.86	15	0.403	0.945
9.Raddella	0.589	0.597	0.127	0.127	-0.77	44	0.448	0.842
10.Haldola	0.519	0.515	0.136	0.151	0.38	41	0.708	0.864
11.Karangoda	0.455	0.454	0.202	0.234	0.013	37	0.989	0.960
12.Dambuluwana	0.51	0.483	0.14	0.166	2.22	26	0.035 *	0.927
13.Amuwala	0.473	0.458	0.141	0.130	1.54	34	0.134	0910
14. Samangama	0.40	0.284	0.156	0.161	7.16	16	0.000 *	0.911
15.Kahawatta	0.432	0.460	0.171	0.190	-1.32	8	0.225	0.942
16. Bloumendhal	0.541	0.379	0.168	0.114	6.09	31	0.000 *	0.480
17. Madampitiya	0.59	0.472	0.22	0.168	4.89	15	0.000 *	0.909
18. Mahawaththa	0.516	0.40	0.214	0.183	2.39	5	0.062	0.832
19. Sammanthranapura	0.538	0.342	0.167	0.099	5.62	9	0.000 *	0.771
20. Mattakkuliya	0.445	0.310	0.180	0.069	2.33	5	0.067	0.682
21. Modara	0.713	0.498	0.213	0.161	6.40	7	0.000 *	0.908

* = $p < 0.05$; confidence level 95%, n = 405.

Almost all the GNDs show high correlation between two indexes and similar narratives can be found in the extant literature (e.g. Cutter, *et al.*, 2014).

Figures 6.19 to 6.24 illustrate the vulnerability conditions (e.g. inundation and physical) of selected sampled households in Kuruwita, Elapatha, and Colombo GNDs.

Figure 6.16: inundated low condition house in Pahalagama, Kuruwita DSD

Figure 6.17: A roof of inundated house in Ganga Ayina village, Raddella, Elapatha DSD

Figure 6.18: Vulnerability is very high when evacuating at deep depth of inundation, Kuruwita DSD.

Figure 6.19: Inundated and contaminated well (used for drinking water) in Kuruwita DSD.

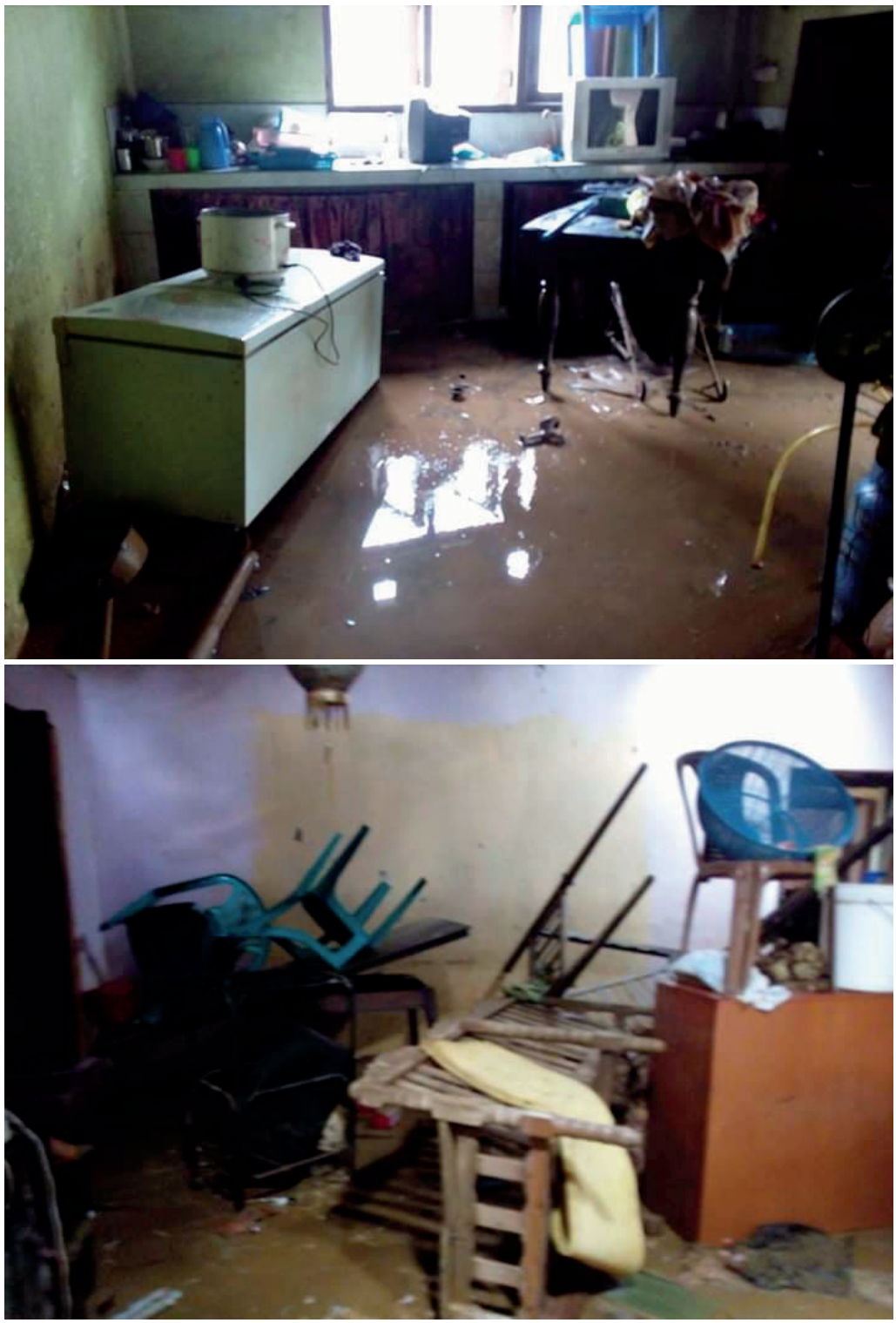

Figure 6.20: Upper and bottom panels – mudded and destroyed households by flood inundation in Karangoda GND, Elapatha DSD.

Figure 6.21: Households' conditions of sampled GNDs in Colombo DSD. upper left and right panels – nearby slums to Kelani River in Sammanthranapura GND; bottom left panel – water-logged household in Bloemendhal GND; bottom right panel- inside of a household in Modara GND.

Earlier mentioned World Bank working paper (Patankar, 2017) also revealed that the poor condition of social networks in Colombo areas. However, that report doesn't mention the way which they collected social networks data and just presented like good social networks or social network status is not good. According to the table 6.10, no significant statistical different between W1 and ESAC indexes observed related to majority of rural GNDs (except six GNDs) while majority of urban GNDs depict with significant different except two GNDs.

Regarding the classification of social vulnerability to flood inundation, it is observed that quite less numbers of households are identified under the very low vulnerability category according to the balance weighting index (W1) index. For instances, Kuruwita (20 / 18%), Elapatha (8/ 4%), and Colombo, 0%. Under the low vulnerability category, 45 (40%), 51 (24%), 20 (26%) households were identified in Kuruwita, Elapatha, and Colombo DSDs respectively. Related to the moderate vulnerability category, predominant percentage of households (e.g. 91 / 42%) reported in Elapatha GNDs compared to Kuruwita (e.g. 35 / 31%) and Colombo (24/ 31%) while rural average with 126 households (38%). Colombo GNDs present the highest percentage of high vulnerable category (e.g. 26/ 33%) compared to Kuruwita (e.g. 11 / 10%) and Elapatha (e.g. 61/ 29%) GNDs with rural average of 72 households (22%). According to the very high vulnerability category, Colombo exemplifies dominant percentage of households (e.g. 8 / 10%) while Kuruwita 2 (2%) and Elapatha 2 (1%) households observed (tables, 6.3, 6.6, 6.9). ESAC index also examples quite similar narratives. Nevertheless, other indexes represent different percentages as well. For examples, W3 index depicts, 17 households (8%) under very high vulnerability category in Elapatha GNDs. Tables, 6.2, 6.5, and 6.8 show some of relevant household level vulnerability information in details. Similarly field observations and focus groups discussions also observed that the majority of inundated households are in rural as well as urban areas more vulnerable to flood inundation in terms of mainly socio-demographic, physical, financial, and health status. It is not hard to discern the inundation depth and household conditions of sampled households according to figures 6.16 to 6.21. More significantly, figure 6.21 implies the rigidity of poverty and the living standards of Colombo sampled households. Moreover, it also hints that they may have very lacks of entitlements (e.g. Sen, 1981) and absent of resource endowments or lacking access to resources (e.g. Cutter, *et al.,* 2014; Frazier, *et al.,* 2014) as well. More importantly, it can be an advantage that this study revealed a broad spectrum of vulnerability results in terms of examining considerably higher number of sampled households in different geographical settings.

Figure 6.22 is more meaningful in presenting a comparative picture of average

social vulnerability to flood inundation in all the GNDs under different indexes. Kithulpe GND in Kuruwita, Raddella GND in Elapatha, and Modara GND in Colombo exemplify the highest scores of vulnerability within each DSD. On other hand, Ihalagama GND in Kuruwita, Samangama GND in Elapatha, and Mattakkuliya GND in Colombo depict with low vulnerable scores in each DSD compared to their rest of GNDs.

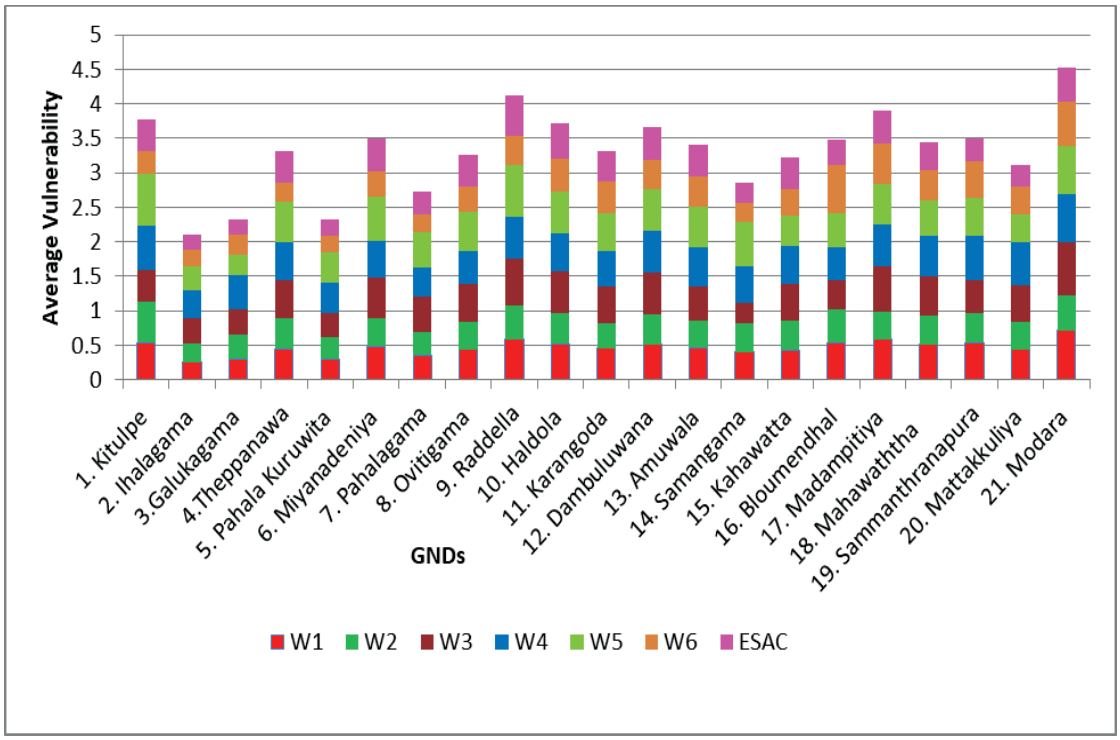

Figure 6.22: Average vulnerability scores of all the GNDs, related to all indexes

And also, average vulnerability scores of each index does not deviate very much within each DSD. Albeit, households level variations are observed. Overall Kuruwita GNDs depict fairly lower vulnerability compared to the GNDs of Elapatha and Colombo DSDs. It is also observed that, vulnerability of Elapatha GNDs and Colombo GNDs exemplify fairly different narratives. This is because Colombo sampled households represent such inherent vulnerability conditions to their settlements and circumstances, by the ways in which difficult to compare with rural context. I have taken photographs of all the households with their exact physical conditions. The physical vulnerability scores of each household are randomly checked with their relevant photographs and almost tallied with their existing conditions. According to the extant literature, no special validation procedures have been carried out by related empirical vulnerability studies.

Figure 6.23 illustrates that GND level average scores of key proxies of IPCC

vulnerability framework namely exposure, sensitivity, and adaptive capacity. These three vulnerability proxies are very pivotal as they represent the exact situation of vulnerability of a system or society. It is observed that the sensitivity scores are fairly low in Kuruwita, Elapatha, and Colombo areas (e.g. 0.34, 0.33, and 0.41 respectively, see appendix table A-15) compared to exposure and adaptive capacity. Also, sensitivity scores are quite similar in all DSDs with some of small regional differences.

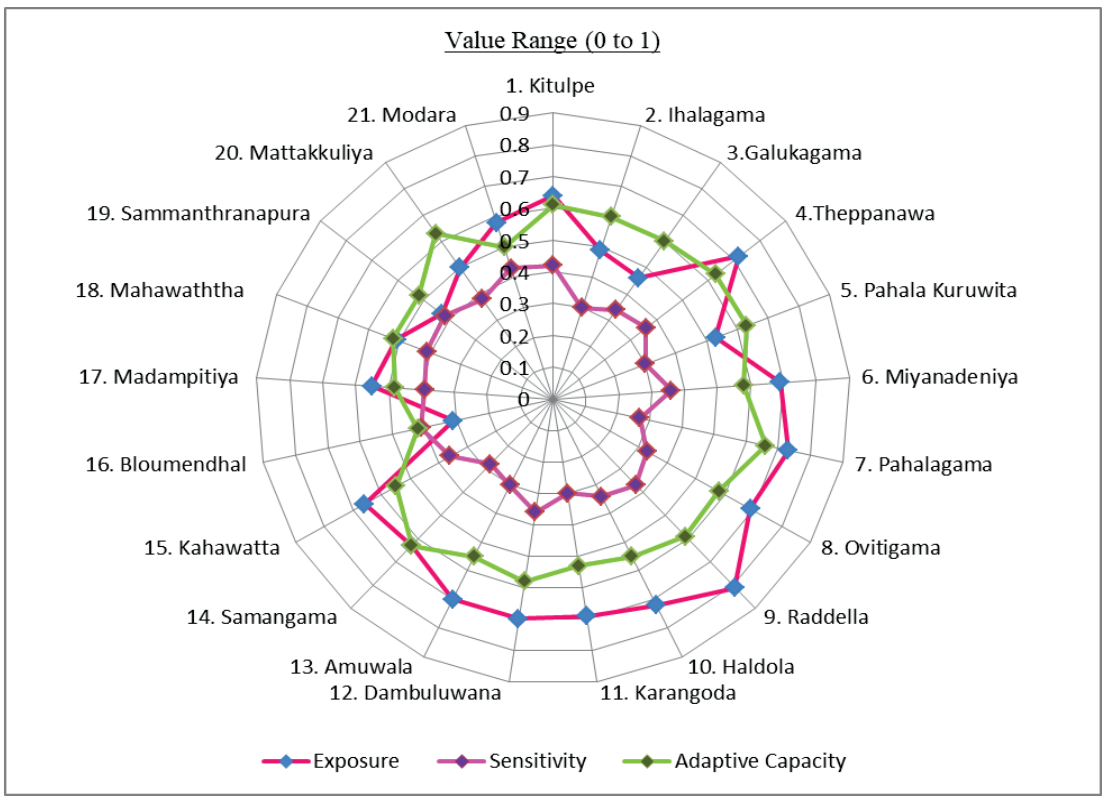

Figure 6.23: Exposure, Sensitivity, and Adaptive capacity of study areas /GND average (relevant data, appendix table A-15).

According to figure 6.23, exposure and adaptive capacity scores are fairly low in Colombo GNDs compared to rural context (e.g. Kuruwita: 0.62/0.61; Elapatha: 0.70/0.57; Colombo: 0.48/0.51). High adaptive capacity implies the prowess of the legacies of socio-economic networks and related social capital. Regionally, Theppanawa GND (Kuruwita) and Raddella GND (Elapatha) represent higher scores of exposure compared to the rest of GNDs. On the other hand, Pahala Kuruwita GND ensures the lowest scores of exposure in rural areas while Bluemendhal GND observed as the lowest score in Colombo. Pahalagama and Samangama GNDs depict the higher scores of adaptive capacity among others

while Mattakkuliya is with the highest score in Colombo.

Adaptive capacity of a society is essential and pivotal as it helps to reduce the risk and vulnerability. The notion of adaptive capacity is foremost important for my study also as it principally concerned the prowess of socio-economic networks and related social capital in terms of ameliorating social vulnerability to flood inundation. According to the extant vulnerability literature, adaptive capacity has fairly been concerned with the resilience science (e.g. Adger, 2006; Waters and Edger, 2017; Cutter, *et al.,* 2014) as it has also been linked with coping capacities (Edger, 1999). However disaster resilience doesn't mean the opposite of social vulnerability (see, Cutter, *et al.*, 2014). Concerning with these insights, in particular, rural areas of my study exemplified with dense adaptive capacity compared to urban context in terms of socio-economic networks and related social capital. Nevertheless, almost all the sampled GNDs revealed that they are considerably vulnerable to flood inundation. This is because adaptive capacity mainly consists of resources, structural notions, and agency (Waters and Edger, 2017). Therefore, similar to Sri Lankan case (this study), many of South Asian countries have been experienced similar consequences and more vulnerable to flood hazards with different magnitudes (e.g. Dewan, 2013, P.5; Jamshed, *et al*., 2019; Jha and Gundimeda, 2019). By contrast, they have been exposed (the notion of exposure) to natural hazards. Notions of exposure and sensitivity are conceptually different, but vulnerability scholars have been categorized vulnerability variables different ways putting them under exposure or sensitivity (e.g. Cutter, *et al.,* 2003; Edger, 2006; Frazier, *et al.,* 2014; Cutter, *et al.,* 2014). This may because the cumulative influence of both the notions has been coming out as vulnerability. All in all, sampled households of this study showed that they are exposed and sensitive to perturbations or stresses or affect to flood inundation. On the other hand, a range of related studies on flood vulnerability have revealed that socio-economic and demographic factors such as age, gender, education, health, family size, and economic status have been crucial causative factors for the vulnerability (e.g. Abbas and Routray, 2014; Rana and Routray, 2016; Jamshed, *et al*., 2019; Frazier, *et al.,* 2014 etc.). Similarly, physical or biophysical components also have been more influential to accelerate the magnitude of vulnerability (Edger, 2006). Despite, the combination of physical variables into social vulnerability quantification have rarely been seen (Jamshed, *et al*., 2019). Therefore, this study also helps to bridge some of gaps in the existing body of literature of vulnerability discourses by applying the empirically based multi facets composite social vulnerability index for the social vulnerability quantification to the flood inundation in rural and urban areas of Sri Lanka. Above examined empirical findings could also be make constructive influence on the policy establishments for flood disasters.

Chapter 7. Conclusion and discussion

7.1. Key findings

This study demonstrates several empirical findings in which solely based on the empirical household survey that was conducted in both rural and urban flood inundated areas covering 21 local administration units belonging to three District Secretariat Divisions (namely Kuruwita, Elapatha, and Colombo DSDs) and two administrative districts (namely Rathnapura and Colombo) in Sri Lanka.

More importantly, study reveals that the socio-economic networks and related social capital legacies effectively mattered in the ameliorating social vulnerability to flood inundation of victim households. In particular, the inundated households in rural geographical settings recognized the socio-economic networks as an instrumental metaphor for healing flood disaster related wounds and worries in terms of preparing, recovering, and reviving their livelihoods. In contrast, the rural villagers have strong trust on their socio-economic networks and they have been interlaced with their family members, relatives, friends, neighbors and the rest of network actors in terms of reciprocal supports and resource mobilizations. Therefore, reciprocal helps and exchanges are pivotal important in revivifying affected livelihoods by all the means. More importantly, major differences of support networks behaviors are observed in related to the urban-rural dichotomy and also among rural areas at lesser magnitudes. In other words, the regional support network behaviors in the flooding events are in stark contrast to the urban networks behaviors is diversified a plenty of ways. Much dense and rich support ties are exemplified in rural areas compared to the urban contexts.

And also, it is observed that the villagers have very strong social capital base and profound historical background of socio-economic networks and social capital in response to flooding events by the ways in which identified as Traditional Social Capital (TSC) in this study. The whole components including traditional preventive apparatuses and values of their traditional village systems had intertwined altogether in response to unexpected encounters like flood disasters and revealed complementary in the nature of functioning.

Another key empirical finding revealed is that the key socio-economic networks measures such as degree density, closeness centrality, and betweenness centrality have changed in response to flood inundation phases. For instance, especially in rural areas, key network measures have decreased from before flood inundation phase to during phase and then have increased in the after phase. In urban areas, key measures have increased from before phase to during phase and

have decreased at after phase with some irregularities. Regional variations of key measures are fairly observed.

Furthermore, network graphs have exemplified structural and evolutionary changes in response to flood inundation phases. Mainly at before and during phases, more clustered and centralized networks structures/topologies observed. Considerable amount of structural holes also depict in those phases. At the after phase, more distributed or decentralized network topologies identified. Fairly different structural evolutionary patterns present between rural and urban contexts and also within sectors. More importantly, reciprocal support activities such as provision of information, food, water and other basic needs; evacuation and moving out belongings; provision of shelters, cleaning up contaminated households and public places; moving in belongings to households, and provisions of emotional and financial supports are strongly influenced for structural evolutionary changes of network topologies. In addition, more structural holes observed at the after phase. It is quite intriguing as well as controversy that many structural holes make with many actors. The reason may be due to the increase of actors without increasing their ties exponentially among each other.

More significantly, the results reveal six social vulnerability score indexes for each and every sampled household based on the Multi Facets Composite Social Vulnerability Index (MFCSVI). The resultant scores are compared with the IPCC vulnerability framework based index (ESAC). More importantly, five key vulnerability components namely, socio-demographic, physical, financial, health and socio-economic networks and social capital covering 31 variables were concerned for the calculation of MFCSVI. More interestingly, fairly similar results revealed by both MFCSVI and ESAC indexes compared to the rest of indexes. The scores of social vulnerability to flood inundation are varied between sectors as well as within sectors. Kuruwita sampled households observed with fairly low scores of vulnerability compared to Elapatha and Colombo sampled households. Regional diversities of vulnerability scores also are observed.

7.2. Research gaps, empirical contributions and theoretical implications

This study contributes to the fields of social vulnerability studies and social networks and related social capital studies by the ways in which investigating of the prowess of socio-economic networks and social capital in the ameliorating social vulnerability to flood inundation in terms of strengthening coping and adapting capacities. This is because up to yet, social networks and social capital based research in the context of vulnerability analysis is lacking. For example, "*the*

application of network analysis to vulnerability theory has been quite recent and limited. Nevertheless, network methods are well suited to address several of the general assumptions underlying vulnerability theory. We expect vulnerability researchers in the future to make increasing use of social network methods" (Zakour and Gillespie, 2013, P.117). And also, social network studies in the disaster context is a new seductive filed (e.g. Jones and Faas, 2017). On the other hand, social vulnerability studies recorded as the least number (18) of applications compare to the rest of physical (145) and institutional vulnerability (48) studies (see, Cho and Chang, 2017). In this context, this study preeminent and significant in combining the notions of socio-economic networks and social capital with social vulnerability in the discourse of flood inundation in Sri Lankan context.

In the extant literature, some of applications found that are concerning on natural disaster analyzing approaches in Sri Lankan context. For example, some have concerned the impacts of aids on Tsunami disaster, (Becchettia, *et al.,* 2017), resilient built environment in cities (Malalgoda, *et al.*, 2016), Seismological applications (Gamage and Venkatesan, 2017), actual and perceived causes of flood risk (Eriyagama, *et al*., 2017), tsunami-based livelihood recovery and social capital (e.g. Minamoto, 2010), evaluation of flood preparedness (Farley, *et al.*, 2017), and recently on flood disaster resilience in war-affected areas (Jayawardana, *et al.,* 2019), and the assessment of flood adaptation (Wagenaar, *et al.*, 2019). One recent World Bank study has carried out on exposure, vulnerability, and ability to respond to floods in Colombo city (Patankar, 2017). This study has focused on flood affected household in the city of Colombo and has applied a qualitative approach used by earlier World Bank work, but has not discussed in the report. It can be used to have some basic understanding about Colombo flood vulnerability. Therefore, up to now, none of empirical applications found on social networks and related social capital applications in the ameliorating social vulnerability to flood inundation. By contrast, empirically, none of social vulnerability quantification approaches are found related to Sri Lankan context in the extant literature. This study fills and bridges the abovementioned gap by demonstrating a new approach. In contrast, this study will be contributed to the existing body of literature of the discourse of social vulnerability to flood inundation in terms of demonstrating the prowess of socio-economic networks. Moreover, examining of reciprocal support mobilization and resource sharing, for example, the investigation of the flows of information, foods, goods, assistants, helps, sheltering, emotional helps, and the provision of other basics needs in which categorized under the social capital, over time (their changes over before, during, after flood inundation) may also fill some gabs in the existing body of literature. In the global context, there are very few studies found on examining of flood disasters with the application of social

network analysis. For example, on community response to a major flood disaster (Stewart, *et al.,* 2014), improving flood response networks (Malone and Kinnear, 2015), flood risk communication strategies (Haer, *et al.,* 2016), adaptive capacity through governance networks (Ceddia, *et al.,* 2017) etc. In this context, the present study differs from those studies as this is demonstrating with the analyzing of the prowess of socio-economic networks and related social capital legacies in ameliorating social vulnerability to flood inundation in variegated rural and urban geographical settings covering 21 local administrative areas and 405 flood affected households.

Especially regarding the investigation of spatiotemporal evolutionary dynamic patterns of socio-economic networks in flood inundation contexts could be more crucial. Especially, regarding the temporal dimension of disaster networks, according to D.M. Varda, none of established theory can be found for studying dynamic nature of networks (Varda, 2017, P.51). This study examined the spatiotemporal evolutionary patterns of socio-economic networks over time (related to before, during, and after flood inundation phases). By contrast, many of disaster network studies (e.g. Misra, *et al.*, 2017; Htein, *et al.,* 2018; Stewart, *et al.,* 2014 etc.) have concerned the networks behaviors of one disaster region or geographical setting. In particular, this study occupied with 15 rural and 6 urban ground level administrative units to investigate socio-economic networks in the context of flood inundation. Therefore, revealed results of this study on spatiotemporal evolutionary patterns of flood disaster network measures and graphs will be more crucial and make theoretical implications on the context.

The application of social capital in the disaster studies has been well documented. Despite, in the Sri Lankan context, only very little number of related applications are found in the extant literature. For instance, social capital for livelihood recovery (Minamoto, 2010) and flood disaster resilience in war-affected areas (Jayawardana, *et al.,* 2019). Since the social capital conception has broadly introduced by J.S. Coleman (see, Coleman, 1988; Coleman, 1993), none of empirical studies found on the examining of traditional bases of social capital in the disaster context. Therefore, this study also demonstrated the notion of traditional social capital (see, Karunarathne and Lee, 2019) in the flood inundation context by contributing to the existing body of literature and could be identified as another crucial theoretical implication of this PhD research.

After the famous pressure and release vulnerability model –PAR (Blaikie, *et al.,* 1994; Wisner, *et al.,* 2004, P.51) and vulnerability as hazard of place model (Cutter, 1996), social vulnerability index (SoVI) can be identified as one of influential social vulnerability applications by the ways in which introduced to quantify country-level social vulnerability to environmental hazards by using socio-

demographic data (Cutter, *et al.,* 2003). And also, some of disaster resilience models like, place-based model of resilience (e.g. Cutter, et al., 2008), measuring of communities' resilience (Cutter, *et al.,* 2010) and baseline resilience indicators for communities (BRIC, e.g. by Cutter, *et al.,* 2014), provides significant examples by developing composite scores and mapping spatial resilience patterns of metropolitan areas. Most notably, IPCC vulnerability framework (e.g. exposure, sensitivity, and adaptive capacity) based assessment (McCarthy, *et al.,* 2001; Field, *et al.,* 2012) has been proliferating by the ways in which examining and analyzing social vulnerability. Moreover, world risk report – 2016 (by United Nations University, 2016) has developed a world risk index comprising the components of exposure, vulnerability, susceptibility, lack of coping capacities, and lack of adaptive capacities and classified world countries in accordance with the composite index.

More importantly, this study will be significant and have also made methodological implication by introducing the application of multi facets composite social vulnerability index MFCSVI mechanism for analyzing of social vulnerability to flood inundation by adding network degree densities of each household in to the algorithm and also with a key components' weighting scheme, compared to the relevant studies (see, Rana and Routray, 2016; Jamshed, *et al.*, 2019 etc.). For the MFCSVI approach, the study considered 31 variables in which related with five key vulnerability components namely, socio-demographic, physical, financial, health, and socio-economic networks and social capital and identified as an advantage. According to the extant literature, a plethora of qualitative and quantitative approaches has been occupied in order to examine the social vulnerability to natural disasters (e.g. Adger, 1999; Adger, 2006; Cutter, 1996; Cutter, *et al.*, 2003; Cutter, *et al.*, 2008; Cutter, *et al.,* 2010 etc.). Among them, one group has been used factor weighting for each and every vulnerability variable based upon expert knowledge and extant literatures (e.g. Abaas and Routray, 2014; Rana and Routray, 2016; Jamshed, *et al.*, 2019 etc.). These applications have used the empirical household survey data and the main drawback behind these applications is that the subjective or arbitrary way of assigning weights for components. The second group has been omitted the application of subjective weightings and occupied with scaling factors considering as equal contributors to the overall vulnerability (e.g. Cutter, *et al.*, 2003; Cutter, *et al*., 2014; Frazier, *et al.*, 2014; Jha and Gundimeda, 2019 etc.). Those scholars have occupied with national level secondary data and applied for districts or much larger geographical settings, in particular by using principal component analysis. In this context, The MFCSVI demonstrates an appropriate mechanism to reduce the arbitrary or subjective way of weighting variables individually as explained in

chapter 3 in detail. According to this mechanism, six composite vulnerability indexes (MFCSVI) are calculated for each household. This mechanism helped to identify overall social vulnerability and also vulnerable local admin units with reference to key vulnerable components. On the other hand, abovementioned relevant studies didn't consider socio-economic networks and social capital very extensively for their vulnerability studies. Therefore, the MFCSVI approach has made clear theoretical implications to the extant literature of social vulnerability quantification.

A limited numbers of social vulnerability studies can be found mainly with the consideration of many physical components and overall social vulnerability causative factors/variables for the vulnerability assessment (e.g. Cho and Chang, 2017). On the other hand, the assessment of social vulnerability to flood disaster in variegated geographical settings is more crucial, in particular for the countries like Sri Lanka which has been experienced adverse flood disasters. Especially, the quantification of social vulnerability to flood disasters will be more influential for planning, mitigation and flood disaster management practices/measures. In addition, an understanding of the differences between rural and urban contexts is also instrumental. Moreover, this work will be more pivotal for the Sri Lankan future vulnerability studies, as this may be the first social vulnerability quantification approach in the context.

All in all, this study's working definition for the notion of social vulnerability to flood inundation is "the status of an individual or a community/group of people in which experienced flood inundations/flood disasters with the lacking of the prowess to be coped with due to a range of economic hardships, weak socio-demographic conditions including weak health circumstances, bad infrastructural conditions, and in particular, with weak socio-economic networks and related social capital endowments". This definition may somehow be a place-specific, because of the status of socio-economic networks and related social capital is one of the key metaphors in the ameliorating social vulnerability to flood inundation in surveyed rural areas, in Sri Lanka.

7.3. Policy implications and recommendations

Regarding policy implementation on the social vulnerability to flood inundation scenarios, a range of regional and national level dilemmas have been driving as major impediments. In particular, urban areas have not been experienced long run effects by flood inundation as the duration of urban flooding events is rather short (e.g. maximum two to three days) compared to the rural areas (e.g. more than two weeks in some of rural cases). Therefore, in order to consider flood

inundation related policy implementations, rural areas should be come to the fore.

The village lifestyle has many difficulties, in spite of village-wide low income and lack of opportunities for earning money. By contrast, they often describe their difficulties from the perspective of their income. Therefore, proliferation of their income sources should be the foremost policy consideration and also have gaining momentums for many village level opportunities. Moreover, potentially, local authorities have to implement some of financially viable aids programs for promoting village-level self-employment opportunities in order to stimulate affected villagers' economy. The village socio-economic networks have been reciprocating social cohesion, empathy, resource exchanges/mobilizations in terms of consolidation of social ties when they meet unexpected encounters, thanks to the rich *de facto* Sri Lankan cultural and societal traditions. Nevertheless, in order to strengthening poorer' monetary status more stable, long-run mechanism is need to be implemented. This can be done by strengthening and refining of existing aids programs for flood victims. On the other hand villagers' financial conditions and household economy are pivotal important in terms of building flood resisting houses and flood resilient programs. Therefore, authorities (central government and local level) have to implement some of financially viable aids programs in order to stimulate villagers' economy. According to respondents, poorer villagers often are being endeavoring to make their home stronger by making one upper level room despite in a situation of a range of economic hardships. In other words, majority of villagers of sampled households in Elapatha as well as Kuruwita GNDs urged that there are no alternative measures to stop or control flooding events and the only solution is to make possible efforts to build an upper flow part that is not for whole the house but only for like just one room in order to secure their belongings and to stay during flooding events. Moreover, yearly floodwaters have adversely affected villagers' psyche in terms of losing and damaging their belongings and event dwelling units. These highlights denote the real situation and difficulties in which they faced along the years in similar or different magnitudes. Villagers are showed that the colored marks of floods levels in their house walls and denote the danger of events to their livelihoods.

Some of previous policy establishments on financial aids programs have caused deep resentments among villagers. In contrast, some of villagers expressed their angers on such practices appeared with party politics. Therefore, one of the central inquiries in which posed by villagers is that lopsided ways of selecting households for aids programs. Despite local authorities' actions sometimes had merely fogged the treatments for local issues. Because of, in some cases may be due to lack of knowledge on local issues or otherwise due to lopsided favorations. Thus, local authorities often GNOs were blamed as they have occupied with some

of wrong doings. However, GNOs strongly denied any kind of culpable in the aiding programs. It is important to mention that GNOs as very close local authorities to villagers, have been doing a range of administrative related jobs and responsibilities in order to conquer villagers' difficulties. In particular, they have been done pivotal managerial roles regarding more difficult situations like flood inundation events. On the other hand, it is observed that villagers generally blame to the officials (e.g. GNOs) who are belonged to opposite political parties of them. Therefore, it is sometimes hard to distinguish and disentangle the exact facts from all stories and impasses. All in all, it is very crucial to take into account the fact that if some of existing aids programs has already been failed or if some of abovementioned lopsided party politics favorations are in linked with aid programs. Because of on the one hand, due to this political influence, some actors have been deserting their networks or village associations. This kind of trends might be made counter-productive consequences on village cooperation. On the other hand, exactly affected households could not be received the exact compensations. In addition, one foremost significant recommendation is that to consider village level socio-economic networks, their pivotal contributions, future challenges, and reciprocal mobilizations into national level policy establishments and considerations in terms of securing and improving their strengths.

It is observed that Gem mining in the beds of rivers is almost reckless and dangerous earning business of villagers and also majority of villagers particularly in Raddella, Dambuluwana, Karangoda, Amuwala, Kahawatta, Pahalagama, Medagama, Ihalagama, and Ovitigama GNDs are involved with this practice. Gem mining has become one of major potential earning methods in their livelihood. Therefore, it is more worthwhile to consider into account to implement policies to secure and sustain their livelihoods by introducing Gem mining related self-employments opportunities may be with combination of *Gem-tourism* which may has gaining momentums for future national development trajectories too. Local level Gem Businessmen also can be incorporated into that process as they are financially very strong. Abovementioned needs not only help to foster villagers' livelihoods strategies but also to support to ameliorate the severity of social vulnerability to flood inundation. In addition to that, during the field data collection, I found that the villagers have quite influential farsighted ideas and proposals which can be considered for policy establishments in fine grain ground level. In other words, villagers have potential business incubators which would be helped them for establishment of self-employment development. This is very important as many of them have not permanent employment at the times of data collection.

Majority of respondents have urged that if they could facilitate with some loans under the low interest rates that would help them to manage their financial

predicaments. In addition, floodwaters have rapidly been depleting the villages' paddy production and this has adversely been affected to the annual paddy cultivation of villages. This situation is quite critical as all the village households solely depend on the village agricultural products. The damage has been varied in accordance with the inundated dates of agricultural lands including tea. Seemingly, village-level paddy production growth retardation is possible to be seen according to the village peasants. In contrast, this growth retardation can be seen in the village paddy fields and productions. This is a prefigured issue by myself in accordance with villagers' facts. Villagers urged that politicians have been pledged that to implement appropriate remedial measures in order to overcome village level difficulties. However villagers also are thinking that politicians have not been doing very much very soon. Field observations proved that some rural areas such as Ovitigama, Raddella, Amuwala, Miyanadeniya, etc. are need immediate remedial actions to implement effective mechanisms to improve their infrastructure facilities.

These considerations should be at the forefront as emerging circumstances on flooding events have been compelling an urgent need of change in policies. These consequences hint that the need of tenable approach for existing issues. All the expecting policy considerations should clearly examine and understand the exact situations of flood affected villages and all should be link with village livelihoods and local environment. Also, policy establishments should implement as the participatory approaches, so all the village level socio-economic networks will be interlinked with the policy establishments which will help to make instrumental and sound approaches.

7.4. Future research foci

The future research foci and directions on socio-economic networks and social capital legacies in response to disaster management are need to be relied on more comprehensive and broad empirical surveys and data collections covering many of disaster prone areas in Sri Lanka. More importantly, there has been lacking efforts and empirical applications on the discourses of social network and social capital in disaster management in the Sri Lankan context. In particular, for such multi-disaster areas, notably like Elapatha DSD, as has been experienced mass flooding events and landslides, some of multi-disciplinary based approaches such as combination of social network analysis, socio-ecological /political aspects, high-resolution remote sensing data and disaster science etc. will be very instrumental. On the other hand, in order to understand the exact structural and temporal evolutionary dynamics of socio-economic networks, more comprehensive

empirical samples are needful as it has not been introduce proper theory or mechanism to investigate the dynamic or temporal dimension of social networks in particular related to disaster events, up to date (see, Varda, 2017, P. 51). Moreover, it may also worthwhile to develop a potential model to determine the Least Vulnerable Locations (LVLs) for the purposes such as regional industrial establishments and development activities by improving the idea of social vulnerability contours. It is also possible to be made regional vulnerability maps containing advancement of vulnerability contour application for the purposes of regional planning.

7.5. Limitations

As described above, the purpose of this study is to examine the role and the efficacy of socio-economic networks in terms of ameliorating social vulnerability to flood inundation. The study also selected an urban study site in order to identify the exact situation in the rural contexts. This is because by investigation of the rural contexts without any of comparison, that may leads to lacking interpretations, imprecise theorizations and imbalance conclusions in national context. This is related to both the socio-economic networks and social vulnerability research paradigms. On the other hands, the study considered particularly the social vulnerability to flood inundation and not considered other natural hazards such as landslides and droughts etc. Also, the study didn't occupy with the physical vulnerability aspects such as geological and rocky structures of residence places, soil morphology and water quality, ground water table conditions, earth fractions and chemical components etc. and albeit this study considered several physical variables (n=9) to the social vulnerability algorithm.

On the other hand, to analyze the chemistry of physical vulnerability need instrumentally driven engineering approaches and that is belonged to another huge research areas. Moreover, the study didn't consider all the affected people and their households belonging to all the study areas for the data collection and selected sample households (e.g. through stratified and simple random sampling) represent all the study areas. Also, it was impossible to be considered many flooding years for the primary data collection (study considered three consecutive years). This is because in order to reduce the possible errors and imprecise interpretation. By contrast, perhaps affected people may have exact and accurate memories on very latest events. For example, they may have good memories in the last two to three years rather than many past years. Importantly, many of rural households, they have marked the past flood inundation levels in their house walls. According to the disaster management center (2017), Kuruwita and Elapatha DSDs have

experienced mass flooding events in the year 2017 and the city of Colombo has experienced recorded flood events in the year 2016. Field visits, observations, and personal experiences obtained during 2018 flooding events were also helped in order to recognize fairly the exact situations and behaviors of socio-economic networks and their reciprocal exchanges and ties over time. There might some of influences from the network data collections as those solely depends on respondents' past memories. By contrast, I asked respondents to name the list of supporters by the ways in which involved at before, during, and after the flood inundation. So, they provided their supporters names and particulars such as length of relationships, place of residence, nature of relationships (relatives, neighbors, friends, and volunteers etc.), type of helps received etc. in accordance with their recent past memories. Albeit during the interviews, particularly in the rural households, other household members supported interviewees to recognize the main supporters' information.

On the other hand, many of supporters are their relatives, neighbors, friends, and GNOs (except volunteers). Therefore, their memories can be believed up to satisfactory level. Frankly speaking, the "sample sizes" might make some inference to the number of ties of households. It is noted that I considered the dynamic nature of socio-economic networks in order to overcome this limitation. Lastly, empirical data collections related to the urban informal settlements were more challenging and difficult by all the means. Because of, there are many underworld activities (such as drug trafficking like heroin) and crimes related to slums and shanties with driving all the bad values. The average response rates of urban households was around 26% (in other words, their consent) compared to the rural context (e.g. 100%). In rural areas, all of respondents highly supported to data collection by providing their information, and also many of them thought that I am collecting data on government purposes (even after I explained my purposes and empirical research course) something like establishment of new aids programs for flood victims and therefore, some of them tried to pose me to select their relatives' homes for data collection. Meanwhile, some of them are forcefully tried to give their inundated households' information and I accepted them and recorded them as informal interviews. I culminated well my empirical data collections amid abovementioned practical impediments. This chapter coincidently explained the key findings, knowledge gap (research gap) and theoretical implications, policy implications, future potential researches, and limitations of this study.

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요약

본 연구는 사회·경제적 네트워크에 대한 주요 견해와 스리랑카 농촌 및 도시 지역에서 홍수 범람의 취약성을 개선에 대한 영향을 다루고 있다. 남아시아 중산층 개발도상국에 속하는 스리랑카는 수십 년 전부터 폭우와 이로 인한 홍수로 인해 여러 부작용을 겪어 왔다. 이에 스리랑카 사회에서는 강력한 사회경제적 네트워크와 상호 호혜적인 인력 동원 및 협력과 이타적 성격으로 홍수로 인한 여러 부작용을 이겨 내었다. 이러한 맥락에서 본 연구는 스리랑카의 홍수 범람에 대한 사회경제적 네트워크의 지리와 관련된 사회적 자본 행위자에 대해 파악하고자 한다.

이에 대한 실증적 연구를 진행하기 위해 스리랑카의 21개의 행정 단위(Grama Niladhari Division, GND)에서 거주하고 있는 405개의 침수 가구를 대상으로 설문 조사를 진행하였다. 설문 조사 대상은 크게 농촌 지역과 도시 지역으로 나눌 수 있으며, 농촌 지역의 경우 15개 GND에 소속된 327 가구, 도시 지역의 경우 6개 GND에 속한 78가구가 이에 해당한다. 또한 추가적인 데이터 수집을 위해 13개월(2018/2019년)에 걸친 가계 설문 조사, 비공식 인터뷰, 포커스 그룹 토론, 현장 관찰을 수행하였다. 주요 연구 방법론으로는 사회적 네트워크 분석 기법(Social Networks Analysis), 사회적 취약성 다변량 지수(Multi Facets Composite Social Vulnerability Index, MFCSVI)을 사용하였으며, 일부 질적 연구 방법을 추가적으로 적용하였다.

연구 결과 네트워크의 성격과 이에 대한 측정치는 시간에 따라 서로 다른 방향 및 크기로 변화 하였으며, 시간과 지리적 공간에 따른 네트워크 연결의 진화적 변화도 관찰할 수 있었다. 특히, 모든 시골 지역 GND와 관련하여, 밀도, 근접성, 중심성과 같은 주요 네트워크 측정치들은 홍수 발생 전 단계 및 발생 단계에서는 감소세를 보이다가, 홍수 발생 이후에는 증가세를 보였다. 이와는 대조적으로 도시에서는 홍수 발생 이전과 발생 단계에서는 주요 네트워크 측정치가 증가세를 보였지만, 발생 이후에는 감소하는 경향을 보였다. 또한,

네트워크 클러스터는 시골 및 도시 지역 모두 홍수 발생 이전 시점과 발생 시점에서 보여지고 있으며 발생 이후에는 감소하는 것으로 나타났다. 네트워크 구조는 대부분의 시골 지역에서 홍수 발생 이후에 지원 네트워크의 조직화가 더욱 짜임새 있는 형태로 전개되었다. 반대로 모든 네트워크의 구조적인 변화는 상호 지원 유대의 행동과 특징에만 기초하고 있다. 사회적 네트워크는 홍수 발생의 이전과 발생 및 이후의 시기에 있어 홍수에 대응하는 데 중심 역할을 해왔다. 특히, 정보, 음식, 물 및 기타 기본적인 생필품의 제공, 살림살이에 대한 청소와 이동, 대피소 제공, 살림살이를 다시 집으로 옮기는 과정, 오염된 주거 환경과 공공 장소에 대한 청소, 각종 재정 지원의 경우 홍수로 입은 피해를 복구하는데 큰 도움이 된 것으로 나타났다. 더욱 중요한 것은 지원 네트워크 행동에 있어 주요한 차이점이 도시와 지방 그리고 작은 규모의 시골 지역들 사이에서 관찰된다는 점이다. 즉, 홍수 사건에서의 지역 지원 네트워크 행동은 도시 네트워크 행동이 다양한 방식으로 다양화되는 것과는 극명한 대조를 이룬다. 즉, 도시에 비해 농촌에서 더 깊은 유대를 바탕으로 한 지원이 이루어지고 있었다. 또한 본 연구는 마을 주민들이 홍수에 대응하기 위하여 사회경제적 네트워크를 강하게 구축하였고, 이에 대한 사회자본의 역사적 배경이 매우 깊다는 것을 관찰하였다. 홍수 범람에 대한 사회적 취약성 점수는 매우 다양한 분포를 보였다. Kuruwita의 가구 표본은 Elapatha, Colombo의 가구 표본에 비하여 상당히 낮은 수준의 취약성을 보였다. 구체적으로 Kuruwita, Elapatha, Colombo DSD에서 평균 취약성 점수는 0.39(최소: 0.01, 최대: 0.875), 0.48(최소: 0.113, 최대: 0.996), 0.56(최소: 0.211, 최대: 0.9999)으로 각각 관찰되었다. 또한 취약성 점수에 대한 지역적 다양성도 관찰된다. 취약성 분포의 공간적 패턴에 대한 차이 또한 취약성 지도(가구 및 GND 수준)를 통해 확인할 수 있었다.

주요어 : 사회경제적 네트워크 유산, 사회적 네트워크 역동성의 지리, 사회적 자본, 상호 지원, 홍수 피해 취약성, 전통적인 사회적 자본(TSC), 홍수 재해 복구

Appendixes

Appendixes 1: Reciprocal Supports and Overall feelings:

Table A-1: Reciprocal supports received by HHs at before, during, and after flood inundation (%)

	Before			During		After	
GNDs	a+b	c+e	d	a+b	c+d+e	a+c+e+f	g
Kitulpe	68.23	11.77	20.00	24.5	75.5	97.5	2.5
Ihalagama	74.0	13.0	13.00	21.23	78.77	91.38	8.62
Galukagama	77.52	12.48	10.00	19.25	80.75	96.48	3.52
Theppanawa	75.52	12.12	12.36	20.52	79.48	90.54	9.46
Pahala Kuruwita	76.53	4.97	18.5	21.56	78.44	95.5	4.5
Miyanadeniya	83.11	3.39	13.5	18.5	81.5	96.54	3.46
Pahalagama	84.92	5.58	9.5	17.61	82.39	91.38	8.62
Ovitigama	74.36	8.14	17.5	20.45	79.55	93.8	6.2
Average	76.77	8.93	14.30	20.45	79.55	94.14	5.86
Raddella	84.4	1.0	14.6	17.25	82.75	89.39	10.61
Haldola	84.94	1.46	13.6	15.89	84.11	94.6	5.4
Karangoda	81.95	2.43	15.62	16.32	83.68	90.34	9.66
Dambuluwana	80.1	5.69	14.21	16.5	83.5	89.74	10.26
Amuwala	79.85	6.79	13.36	17.2	82.8	91.65	8.35
Samangama	79.85	3.65	16.5	19.41	80.59	96.55	3.45
Kahawatta	76.75	2.6	20.65	21.32	78.68	92.2	7.8
Average	81.12	3.37	15.51	17.7	82.3	92.07	7.93
Bluomendal	82.6	17.4	0.0	21.36	78.64	100.0	0.0
Madampitiya	86.8	13.2	0.0	22.5	77.5	100.0	0.0
Mahawaththa	100.0	0.0	0.0	0.0	100.0	100.0	0.0
Sammanthranapura	100.0	0.0	0.0	0.0	100.0	100.0	0.0
Mattakkuliya	100.0	0.0	0.0	0.0	100.0	100.0	0.0
Modara	100.0	0.0	0.0	0.0	100.0	100.0	0.0
Urban Average	94.9	5.1	0.0	7.31	92.69	100.0	0.0
Rural Average	78.8	6.34	14.86	19.8	80.2	93.17	6.83

Notes: a- information provision; b- evacuation and moving out belongings (members of the same household have evacuated at different times according to the availability of facilities); c-food, water and other basic needs including health supports; d- provision of shelters; e- emotional supports; f- move in back belongings of HHs, cleaning contaminated (e.g. mudded) HHs and public places; g- financial support. *Source*: Own household survey, 2018/2019.

Table A-2: Overall feelings (average)/ before flooding (Q. no 60.1 – 60.11)

GNDs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Kitulpe	1.1	1.1	1.2	1.7	2.1	1.4	4.5	4.8	1.5	2.7	1.1
Ihalagama	1.25	1.25	1.3	1.6	2.9	1.2	4.6	5	1.1	3.3	1.1
Galukagama	1.1	1.1	1.1	1.7	3.4	1.0	4.8	4.6	1.0	3.5	1.0
Theppanawa	1.38	1.13	1.1	1.5	3.9	1.5	5	4.9	1.5	3.4	1.1
Pahala Kuruwita	1.09	1.0	1.0	1.18	3.3	1.1	4.9	4.5	1.1	3.4	1.1
Miyanadeniya	1.24	1.44	1.6	2.28	2.7	2.0	4.7	4.7	1.4	3.6	1.3
Pahalagama	1.4	1.13	1.1	1.5	2.8	1.5	5	5	1.5	3.6	1.1
Ovitigama	1.25	1.19	1.5	1.38	2.9	1.5	4.8	4.8	1.6	3.4	1.2
Average	**1.2**	**1.2**	**1.2**	**1.6**	**3.0**	**1.4**	**4.8**	**4.8**	**1.3**	**3.4**	**1.1**
Raddella	1.22	1.13	1.1	1.67	2.5	1.7	5	4.8	1.2	3.5	1.1
Haldola	1.17	1.26	1.3	1.36	2.8	1.6	4.7	4.9	1.5	2.7	1.1
Karangoda	1.18	1.13	1.1	1.5	3.3	1.5	5	4.9	1.1	3.1	1.1
Dambuluwana	1.7	1.04	1.1	1.19	3.2	1.6	4.6	5	1.1	3.6	1.1
Amuwala	1.43	1.11	1.3	1.49	3.2	1.1	4.4	4.9	1.3	3.3	1.0
Samangama	1.24	1.18	1.1	1.29	3.3	1.2	4.8	5	1.2	3.4	1.1
Kahawatta	1.67	1.61	1.7	2.0	2.3	1.9	4.8	4.5	1.6	3.1	1.4
Average	**1.4**	**1.2**	**1.2**	**1.5**	**2.9**	**1.5**	**4.8**	**4.9**	**1.3**	**3.2**	**1.1**
Bluomendal	2.19	2.09	2.5	2.31	3.1	2.7	2.8	2.9	2.9	3.4	2.1
Madampitiya	2.63	2.69	2.5	2.31	3.9	2.6	3.6	3.3	4.2	3.8	2.0
Mahawaththa	2.33	2.67	2.7	2.33	4.2	2.8	3.2	3.7	3.2	3.0	3.0
Sammanthranapura	1.9	2.4	2.5	2.1	4.0	2.7	2.8	3.0	2.7	3.5	2.8
Mattakkuliya	2.17	2.1	2.2	2.15	5.0	2.7	2.5	3.2	3.0	4.3	2.8
Modara	2.25	2.0	2.4	2.38	4.0	1.9	3.3	3.5	3.5	2.8	2.1
Urban Average	**2.2**	**2.3**	**2.5**	**2.3**	**4.0**	**2.6**	**3.0**	**3.3**	**3.3**	**3.5**	**2.5**
Rural Average	**1.3**	**1.2**	**1.2**	**1.6**	**3.0**	**1.5**	**4.8**	**4.8**	**1.3**	**3.3**	**1.1**

Notes: **1**. I received all the necessary information before the flooding; **2**. I received very good helps by friends; **3**. I received very good helps by neighbors; **4**. I received very good helps by the Government; **5**. I received very good helps by volunteers; **6**. Local authorities announced necessary information on right time; **7**. No one helped me; **8**. I did everything myself; **9**. I have strong trust about others on readying for flooding; **10**. I also helped my neighbors and friends to move out things before floods; **11**. We collaborated with others to overcome our difficulties.

Responses: (1). Strongly Agree; (2). Agree; (3). Neutral; (4). Disagree; (5). Strongly disagree. Source: Own HHs survey, 2018/2019

Table A- 3: Overall feelings (average)/ during flooding (Q. no 61.1 – 61.15)

GNDs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Kitulpe	1.6	1.1	1.0	2.0	1.5	2.0	4.7	4.6	4.7	1.7	1.5	1.3	3.0	1.1	4.4
Ihalagama	1.6	1.1	1.1	1.9	1.3	1.9	4.9	5	4.8	1.4	1.2	1.2	3.4	1.2	4.1
Galukagama	1.4	1.0	1.0	1.4	1.4	1.7	4.9	5	5	1.3	1.2	1.2	3.1	1.2	3.6
Theppanawa	1.6	1.1	1.1	1.4	1.1	1.4	5	5	5	1.4	1.2	1.1	3.0	1.2	5
Pahala Kuruwita	1.2	1.1	1.0	1.3	1.1	1.6	4.8	4.6	4.2	1.1	1.1	1.0	2.9	1.7	4.6
Miyanadeniya	2.1	1.3	1.3	2.1	1.5	2.2	4.6	4.5	4.6	1.7	1.6	1.4	3.4	1.3	5
Pahalagama	1.4	1.3	1.0	1.3	1.5	1.5	4.7	4.6	4.3	1.3	1.2	1.0	2.8	1.0	5
Ovitigama	1.2	1.1	1.1	1.6	1.5	1.8	4.8	5.0	4.6	1.9	1.3	1.3	2.9	1.1	5
Average	**1.5**	**1.1**	**1.1**	**1.6**	**1.4**	**1.8**	**4.8**	**4.8**	**4.7**	**1.5**	**1.3**	**1.2**	**3.1**	**1.2**	**4.6**
Raddella	1.5	1.2	1.2	1.6	1.2	1.7	4.9	4.8	4.7	1.5	1.4	1.3	3.0	1.2	4.8
Haldola	1.6	1.3	1.4	1.6	1.4	1.7	4.8	4.8	4.7	1.5	1.4	1.5	3.5	1.4	4.5
Karangoda	1.3	1.2	1.2	1.3	1.1	1.8	4.9	4.7	4.6	1.4	1.3	1.2	3.2	1.2	4.5
Dambuluwana	1.7	1.2	1.2	1.5	1.2	1.6	4.7	4.6	4.5	1.5	1.4	1.3	3.4	1.3	4.4
Amuwala	1.9	1.5	1.5	1.7	1.6	1.7	4.8	4.7	4.8	1.6	1.5	1.4	3.5	1.4	4.2
Samangama	1.5	1.1	1.1	1.7	1.5	2.5	5	5	5	2.2	1.6	1.5	3.7	1.1	2.0
Kahawatta	1.6	1.1	1.2	1.8	1.6	2.1	5	5	4.5	1.7	1.7	1.6	3.9	1.3	1.1
Average	**1.6**	**1.2**	**1.3**	**1.6**	**1.4**	**1.9**	**4.9**	**4.8**	**4.7**	**1.6**	**1.5**	**1.4**	**3.5**	**1.3**	**3.6**
Bluomendal	1.8	1.5	1.5	2.0	1.8	2.2	4.0	4.4	4.3	1.9	1.7	1.9	3.9	1.5	1.4
Madampitiya	1.4	1.4	1.6	1.5	1.4	2.0	4.1	4.3	3.9	2.1	2.1	2.2	3.6	1.4	1.4
Mahawaththa	1.2	1.2	2.7	1.2	1.3	2.2	4.5	4.5	3.5	2.5	2.5	2.2	4.2	1.4	1.0
Sammanthranapura	1.3	1.2	1.6	1.2	1.2	1.3	3.8	3.8	2.8	2.4	1.2	1.2	4.0	2.2	1.3
Mattakkuliya	1.2	1.5	2.8	1.2	1.4	2.5	4.2	4.3	2.5	1.3	2.0	1.5	3.8	1.8	1.5
Modara	1.8	1.8	1.6	1.8	1.9	1.9	3.9	3.4	2.9	1.9	2.0	2.0	3.8	1.7	1.6
Urban Average	**1.5**	**1.4**	**2.0**	**1.5**	**1.5**	**2.0**	**4.1**	**4.1**	**3.3**	**2.0**	**1.9**	**1.8**	**3.9**	**1.7**	**1.4**
Rural Average	**1.5**	**1.2**	**1.2**	**1.6**	**1.4**	**1.8**	**4.8**	**4.8**	**4.7**	**1.6**	**1.4**	**1.3**	**3.3**	**1.2**	**4.1**

Notes: **1**. I received all the necessary information on evacuation; **2**. I received very good helps by friends; **3**. I received very good helps by neighbors; **4**. I received very good helps by the Government and forces; **5**. I received very good helps by volunteers; **6**. Local authorities announced necessary information on right time; **7**. No one helped me; **8**. I did everything myself; **9**. I did feel run out food, water, and other basics need during the floods; **10**. I received all the basics needs during the floods; **11**. I have strong trust about others on evacuation flooding. **12**. My overall rate about helps rendered by other during the floods; **13**. I also helped my neighbors and friends to evacuate during floods; **14**. We collaborated with other to overcome our difficulties; **15**. We had alternative access roads to evacuate during the floods.

Responses: (1). Strongly Agree; (2). Agree; (3). Neutral; (4). Disagree; (5). Strongly disagree.

Source: Own HHs survey, 2018/2019

Table A-4: Overall feelings (average)/ after flooding (Q. no 61.1 – 61.15)

GNDs	1	2	3	4	5	6	7	8	9	10	11	12	13
Kitulpe	1.8	1.0	1.0	2.1	1.3	2.4	4.7	4.4	4.2	3.1	1.0	1.1	1.1
Ihalagama	1.4	1.2	1.1	1.9	1.1	1.9	4.9	4.9	4.8	3.3	1.1	1.1	1.1
Galukagama	1.3	1.1	1.1	1.5	1.2	1.9	4.9	4.9	4.9	3.5	1.4	1.2	1.2
Theppanawa	1.6	1.0	1.0	1.7	1.0	1.4	4.9	5.0	4.4	3.4	1.8	1.1	1.1
Pahala Kuruwita	1.6	1.3	1.0	1.3	1.1	1.3	4.8	4.9	4.7	4.0	1.0	1.0	1.0
Miyanadeniya	2.1	1.3	1.2	2.3	1.5	2.3	4.6	4.5	4.3	3.3	1.3	1.3	1.4
Pahalagama	1.8	1.0	1.0	1.5	1.2	1.8	4.6	4.7	4.4	3.4	1.8	1.3	1.3
Ovitigama	1.4	1.2	1.1	2.0	1.3	2.0	5	4.7	4.4	3.6	1.1	1.0	1.0
Average	**1.6**	**1.1**	**1.1**	**1.8**	**1.2**	**1.9**	**4.8**	**4.8**	**4.5**	**3.5**	**1.3**	**1.1**	**1.2**
Raddella	1.3	1.3	1.2	1.6	1.2	1.6	4.9	4.9	4.7	3.6	1.6	1.6	1.2
Haldola	1.4	1.4	1.3	1.5	1.4	1.9	4.8	4.7	4.8	4.5	1.4	1.3	1.4
Karangoda	1.2	1.1	1.2	1.1	1.2	1.7	4.8	4.9	4.8	4.5	1.2	1.2	1.1
Dambuluwana	1.8	1.3	1.2	1.3	1.2	1.5	4.7	4.9	4.7	2.0	1.3	1.3	1.2
Amuwala	1.7	1.2	1.3	1.4	1.3	1.6	4.8	4.8	4.6	1.8	1.4	1.4	1.3
Samangama	1.6	1.1	1.1	1.9	1.2	2.3	5	5	5	4.2	1.3	1.1	1.2
Kahawatta	1.8	1.1	1.2	1.7	1.22	2.0	4.78	4.8	4.44	2.78	1.67	1.44	1.4
Average	**1.5**	**1.2**	**1.2**	**1.5**	**1.2**	**1.8**	**4.8**	**4.9**	**4.7**	**3.3**	**1.4**	**1.3**	**1.3**
Bluomendal	1.9	1.4	1.5	1.8	1.63	1.6	4.31	4.3	4.25	1.81	1.53	1.5	1.47
Madampitiya	2.8	2.4	3.1	2.4	1.5	1.69	4.38	4.19	3.0	1.2	2.31	2.31	3.0
Mahawaththa	4.2	3.3	3.2	2.7	1.2	2.8	4.3	4.5	3.33	1.0	3.5	2.0	3.0
Sammanthranapura	1.3	1.4	1.4	1.2	1.4	1.4	4.1	4.0	2.7	1.5	1.4	1.2	2.3
Mattakkuliya	1.5	1.2	1.2	1.2	1.3	1.2	1.7	4.0	1.83	1.2	1.2	1.2	2.2
Modara	1.5	1.5	1.6	1.6	1.6	2.13	4.13	3.75	2.5	1.4	1.6	1.5	1.9
Urban Average	**2.2**	**1.9**	**2.0**	**1.8**	**1.4**	**1.8**	**3.8**	**4.1**	**2.9**	**1.4**	**1.9**	**1.6**	**2.3**
Rural Average	**1.6**	**1.2**	**1.1**	**1.6**	**1.2**	**1.8**	**4.8**	**4.8**	**4.6**	**3.4**	**1.4**	**1.2**	**1.2**

Notes: **1**. I received all the necessary information after the flooding; **2.** I received very good helps by friends; **3**. I received very good helps by neighbors; **4**. I received very good helps by the Government and forces; **5.** I received very good helps by volunteers; **6.** Local authorities announced necessary information on right time; **7**. No one helped me; **8.** I did everything myself; **9**. I did feel run out food, water, and other basics need after the floods; **10**. I am feeling, I have lost everything after flooding; **11**. My overall rate about helps rendered by other after the floods; **12**. I also helped my neighbors and friends to move in after floods; **13**. We collaborated with others to overcome our difficulties.

Responses: (1). Strongly Agree; (2). Agree; (3). Neutral; (4). Disagree; (5). Strongly disagree.

Source: Own HHs survey, 2018/2019

Table A-5: GNO's Role and Positions in the socio-economic network evolutions

GNDs	Before			During			After		
	D	Close	Bet	D	Close	Bet	D	Close	Bet
Kitulpe	0.250	0.317	0.463	0.308	0.377	0.523	0.116	0.434	0.127
Ihalagama	0.357	0.318	0.451	0.343	0.354	0.644	0.204	0.467	0.259
Galukagama	0.204	0.234	0.321	0.260	0.279	0.397	0.209	0.481	0.253
Theppanawa	0.161	0.341	0.266	0.211	0.284	0.135	0.188	0.368	0.141
Pahala Kuruwita	0.389	0.353	0.500	0.348	0.329	0.359	0.189	0.493	0.143
Miyanadeniya	0.400	0.301	0.453	0.294	0.343	0.417	0.286	0.432	0.230
Pahalagama	0.250	0.302	0.308	0.235	0.315	0.221	0.111	0.424	0.028
Ovitigama	0.219	0.278	0.535	0.296	0.250	0.264	0.229	0.490	0.234
Average	**0.279**	**0.306**	**0.412**	**0.287**	**0.316**	**0.370**	**0.192**	**0.449**	**0.177**
Raddella	0.197	0.198	0.266	0.164	0.322	0.639	0.245	0.415	0.612
Haldola	0.289	0.249	0.454	0.208	0.199	0.412	0.109	0.338	0.294
Karangoda	0.243	0.247	0.393	0.299	0.324	0.475	0.115	0.290	0.484
Dambuluwana	0.277	0.311	0.575	0.217	0.266	0.487	0.125	0.348	0.171
Amuwala	0.133	0.191	0.316	0.136	0.193	0.150	0.118	0.328	0.260
Samangama	0.116	0.156	0.110	0.071	0.194	0.023	0.088	0.329	0.351
Kahawatta	0.167	0.261	0.246	0.167	0.261	0.078	0.088	0.333	0.211
Average	**0.203**	**0.230**	**0.337**	**0.180**	**0.251**	**0.323**	**0.127**	**0.340**	**0.340**
Bluomendal	0.070	0.156	0.050	0.184	0.235	0.191	0.115	0.129	0.106
Madampitiya	0.143	0.236	0.224	0.333	0.450	0.304	0	0	0
Mahawaththa	0.222	0.257	0.111	0.375	0.500	0.554	0.222	0.321	0.056
Sammanthranapur	0.133	0.227	0.076	0.231	0.310	0.096	0.267	0.288	0.267
Mattakkuliya	0	0	0	0.375	0.400	0.464	0	0	0
Modara	0	0	0	0.300	0.385	0.033	0.200	0.227	0.111
Urban Average	**0.095**	**0.146**	**0.077**	**0.300**	**0.380**	**0.274**	**0.134**	**0.161**	**0.090**
Rural Average	**0.241**	**0.268**	**0.375**	**0.234**	**0.284**	**0.347**	**0.159**	**0.394**	**0.259**

Notes: Note: D = degree density; Close = closeness; Bet = betweenness ; all the values are normalized (by UCINET, Report Normalized)

Source: Own calculation on HHs survey data, 2018/2019

Appendixes 2: Trust and Solidarity

Table A-6: Trusting their Community (frequency and percentage)

GNDs	**1**	**2**	**3**	**4**	**5**
Kitulpe	5 (50)	2 (20)	2 (20)	1 (10)	0
Ihalagama	8 (50)	5 (31.3)	2 (12.4)	1 (6.3)	0
Galukagama	10 (38.5)	10 (38.5)	4 (15.3)	2 (7.7)	0
Theppanawa	3 (33.3)	4 (44.5)	1 (11.1)	1 (11.1)	0
Pahala Kuruwita	4 (36.4)	5 (45.4)	2 (18.2)	0	0
Miyanadeniya	8 (44.4)	5 (27.8)	2 (11.1)	2 (11.1)	1 (5.6)
Pahalagama	3 (37.5)	3 (37.5)	1 (12.5)	1 (12.5)	0
Ovitigama	7 (43.7)	5 (31.3)	2 (12.5)	2 (12.5)	0
Average	**48 (42.1)**	**39 (34.2)**	**16 (14)**	**10 (8.8)**	**1 (0.9)**
Raddella	19 (42.2)	19 (42.2)	3 (6.7)	1 (2.2)	3 (6.7)
Haldola	16 (38.1)	17 (40.4)	6 (14.3)	1 (2.4)	2 (4.8)
Karangoda	15 (39.5)	15 (39.5)	6 (15.8)	1 (2.6)	1 (2.6)
Dambuluwana	11 (40.7)	8 (29.6)	5 (18.5)	2 (7.5)	1 (3.7)
Amuwala	15 (42.9)	11 (31.4)	6 (17.1)	1 (2.9)	2 (5.7)
Samangama	11 (64.7)	5 (29.4)	1 (5.9)	0	0
Kahawatta	5 (55.6)	1 (11.1)	2 (22.1)	1 (11.1)	0
Average	**92 (43.2)**	**76 (35.7)**	**29 (13.6)**	**7 (3.3)**	**9 (4.2)**
Bluomendal	3 (9.4)	9 (28.1)	8 (25)	9 (28.1)	3 (9.4)
Madampitiya	3 (18.8)	4 (25)	5 (31.3)	3 (18.8)	1 (6.2)
Mahawaththa	2 (33.3)	1 (16.7)	2 (33.3)	1 (16.7)	0
Sammanthranapura	1 (10)	4 (40)	3 (30)	1 (10)	1 (10)
Mattakkuliya	1 (16.7)	2 (33.3)	2 (33.3)	1 (16.7)	0
Modara	1 (12.5)	2 (25)	3 (37.5)	1 (12.5)	1 (12.5)
Urban Average	**11 (14.1)**	**22 (28.2)**	**23 (29.5)**	**16 (20.5)**	**6 (7.7)**
Rural Average	**140 (42.7)**	**115 (35.2)**	**45 (13.8)**	**17 (5.2)**	**10 (3.1)**

Notes: **1**-Strongly agree, **2**- Agree, **3**-Neutral, **4**-Disagree, **5**-Strongly disagree

Source: Own HHs survey, 2018/2019

Table A-7: Willingness to helps

GNDs	**1**	**2**	**3**	**4**	**5**
Kitulpe	5 (50)	3 (30)	2 (20)	0	0
Ihalagama	8 (50)	5 (31.3)	2 (12.4)	1 (6.3)	0
Galukagama	11 (42.3)	9 (34.6)	4 (15.4)	2 (7.7)	0
Theppanawa	5 (55.6)	3 (33.3)	1 (11.1)	0	0
Pahala Kuruwita	5 (45.5)	5 (45.5)	1 (9)	0	0
Miyanadeniya	8 (44.4)	5 (27.7)	3 (16.7)	1 (5.6)	1 (5.6)
Pahalagama	4 (50)	2 (25)	1 (12.5)	1 (12.5)	0
Ovitigama	9 (56.2)	4 (25)	1 (6.3)	2 (12.5)	0
Average	**55 (48.2)**	**36 (31.6)**	**15 (13.2)**	**7 (6.1)**	**1 (9)**
Raddella	18 (40)	21 (46.7)	3 (6.7)	1 (2.2)	2 (4.4)
Haldola	16 (38.1)	17 (40.4)	6 (14.3)	1 (2.4)	2 (4.8)
Karangoda	19 (50)	11 (28.9)	6 (15.9)	1 (2.6)	1 (2.6)
Dambuluwana	11 (40.7)	8 (29.6)	6 (22.3)	0	2 (7.4)
Amuwala	14 (40)	12 (34.2)	7 (20)	1 (2.9)	1 (2.9)
Samangama	11 (64.7)	5 (29.4)	1 (5.9)	0	0
Kahawatta	3 (33.3)	3 (33.3)	2 (22.2)	1 (11.2)	0
Average	**92 (43.2)**	**77 (36.2)**	**31 (14.6)**	**5 (2.3)**	**8 (3.7)**
Bluomendal	5 (15.6)	7 (21.9)	8 (25)	11 (34.4)	1 (3.1)
Madampitiya	2 (12.5)	5 (31.3)	6 (37.5)	3 (18.7)	0
Mahawaththa	1 (16.7)	2 (33.3)	2 (33.3)	1 (16.7)	0
Sammanthranapura	2 (20)	3 (30)	3 (30)	2 (20)	0
Mattakkuliya	1 (16.7)	2 (33.3)	2 (33.3)	1 (16.7)	0
Modara	2 (25)	1 (12.5)	4 (50)	1 (12.5)	0
Urban Average	**13 (16.7)**	**20 (25.6)**	**25 (32.1)**	**19 (24.3)**	**1 (1.3)**
Rural Average	**147 (45)**	**113 (34.4)**	**46 (14.1)**	**12 (3.7)**	**9 (2.8)**

Notes: **1**-Strongly agree, **2**- Agree, **3**-Neutral, **4**-Disagree, **5**-Strongly disagree

Source: Own HHs survey, 2018/2019

Table A-8: People do not trust each other when they borrowing and lending money

GNDs	**1**	**2**	**3**	**4**	**5**
Kitulpe	0	0	2 (20)	3 (30)	5 (50)
Ihalagama	0	1 (6.3)	1 (6.3)	8 (50)	6 (37.4)
Galukagama	0	0	5 (19.2)	12 (46.2)	9 (34.6)
Theppanawa	0	1 (11.1)	1 (11.1)	2 (22.2)	5 (55.6)
Pahala Kuruwita	0	0	1 (9)	5 (45.5)	5 (45.5)
Miyanadeniya	2 (11.1)	0	1 (5.6)	6 (33.3)	9 (50)
Pahalagama	0	0	2 (25)	3 (37.5)	3 (37.5)
Ovitigama	2 (12.4)	3 (18.8)	3 (18.8)	8 (50)	0
Average	**2 (1.8)**	**4 (3.5)**	**16 (14)**	**42 (36.8)**	**50 (43.9)**
Raddella	0	3 (6.7)	4 (8.9)	23 (51.1)	15 (33.3)
Haldola	0	3 (7.1)	11 (26.2)	15 (35.7)	13 (31)
Karangoda	2 (5.3)	3 (7.9)	7 (18.4)	15 (39.5)	11 (28.9)
Dambuluwana	1 (3.7)	2 (7.5)	4(14.8)	11 (40.7)	9 (33.3)
Amuwala	1 (2.9)	2 (5.7)	6 (17.1)	17 (48.6)	9 (25.7)
Samangama	0	0	1 (5.9)	6 (35.3)	10 (58.8)
Kahawatta	0	1 (11.2)	2 (22.2)	3 (33.3)	3 (33.3)
Average	**4 (1.9)**	**14 (6.6)**	**35 (16.3)**	**90 (42.3)**	**70 (32)**
Bluomendal	3 (9.4)	11 (34.4)	6 (18.8)	10 (31.3)	2 (6.3)
Madampitiya	3 (18.8)	5 (31.3)	1 (6.3)	4 (25)	3 (18.8)
Mahawaththa	0	2 (33.3)	1 (16.7)	2 (33.3)	1 (16.7)
Sammanthranapura	2 (20)	2 (20)	1 (10)	4 (40)	1 (10)
Mattakkuliya	0	1 (16.7)	2 (33.3)	2 (33.3)	1 (16.7)
Modara	0	3 (37.5)	2 (25)	2 (25)	1 (12.5)
Urban Average	**8 (10.3)**	**24 (30.8)**	**13 (16.7)**	**24 (30.7)**	**9 (11.5)**
Rural Average	**6 (1.8)**	**18 (5.5)**	**51 (15.6)**	**132 (40.4)**	**120 (36.7)**

Notes: **1**-Strongly agree, **2**- Agree, **3**-Neutral, **4**-Disagree, **5**-Strongly disagree

Source: Own HHs survey, 2018/2019

Table A-9: Do you help each other, when they need?

GNDs	**1**	**2**	**3**	**4**	**5**
Kitulpe	5 (50)	5 (50)	0	0	0
Ihalagama	7 (43.7)	8 (50)	1 (6.3)	0	0
Galukagama	13 (50)	12 (46.2)	1 (3.8)	0	0
Theppanawa	4 (44.4)	5 (55.6)	0	0	0
Pahala Kuruwita	5 (45.5)	5 (45.5)	1 (9)	0	0
Miyanadeniya	10 (55.6)	5 (27.7)	1 (5.6)	2 (11.1)	0
Pahalagama	4 (50)	4 (50)	0	0	0
Ovitigama	8 (50)	4 (25)	4 (25)	0	0
Average	**56 (9.1)**	**48 (42.1)**	**8 (7)**	**2 (1.8)**	**0**
Raddella	22 (48.9)	17 (37.8)	6 (13.3)	0	0
Haldola	19 (45.2)	16 (38.1)	7 (16.7)	0	0
Karangoda	17 (44.7)	15 (39.5)	5 (13.2)	1 (2.6)	0
Dambuluwana	14 (51.9)	8 (29.6)	2 (7.4)	3 (11.1)	0
Amuwala	16 (45.7)	14 (40)	4 (11.4)	1 (2.9)	0
Samangama	10 (58.8)	7 (41.2)	0	0	0
Kahawatta	3 (33.3)	5 (55.6)	1 (11.1)	0	0
Average	**101(47.4)**	**82 (38.5)**	**24 (11.3)**	**6 (2.8)**	**0**
Bluomendal	5 (15.6)	10 (31.3)	11 (34.4)	5 (15.6)	1 (3.1)
Madampitiya	2 (12.5)	5 (31.2)	3 (18.8)	4 (25)	2 (12.5)
Mahawaththa	2 (33.3)	3 (50)	0	1 (16.7)	0
Sammanthranapura	1 (10)	5 (50)	3 (30)	1 (10)	0
Mattakkuliya	1 (16.7)	3 (50)	2 (33.3)	0	0
Modara	2 (25)	2 (25)	2 (25)	2 (25)	0
Urban Average	**13 (16.7)**	**28 (35.9)**	**21 (26.9)**	**13 (16.7)**	**3 (3.8)**
Rural Average	**157 (48)**	**130 (39.8)**	**32 (9.8)**	**8 (2.4)**	**0**

Notes: **1**-Strongly agree, **2**- Agree, **3**-Neutral, **4**-Disagree, **5**-Strongly disagree

Source: Own HHs survey, 2018/2019

Table A-10: Helping each other in flooding events /this is to have their general perception on helps collaborations except overall feelings

GNDs	**1**	**2**	**3**	**4**	**5**
Kitulpe	4 (40)	5 (50)	1 (10)	0	0
Ihalagama	7 (43.7)	6 (37.5)	3 (18.8)	0	0
Galukagama	17 (65.4)	6 (23.1)	1 (3.8)	2 (7.7)	0
Theppanawa	5 (55.6)	3 (33.3)	0	1 (11.1)	0
Pahala Kuruwita	7 (63.6)	3 (27.3)	1 (9.1)	0	0
Miyanadeniya	9 (50)	5 (27.8)	2 (11.1)	2 (11.1)	0
Pahalagama	4 (50)	3 (37.5)	1 (12.5)	0	0
Ovitigama	7 (43.7)	6 (37.5)	2 (12.5)	1 (6.3)	0
Average	**60 (52.6)**	**37 (32.5)**	**11 (9.6)**	**6 (5.3)**	**0**
Raddella	22 (48.8)	16 (35.6)	4 (8.9)	3 (6.7)	0
Haldola	18 (42.9)	17 (40.5)	3 (7.1)	3 (7.1)	1 (2.4)
Karangoda	16 (42.2)	14 (36.8)	1 (2.6)	6 (15.8)	1 (2.6)
Dambuluwana	12 (44.4)	9 (33.3)	2 (7.4)	3 (11.2)	1 (3.7)
Amuwala	13 (37.1)	14 (40)	0	6 (17.2)	2 (5.7)
Samangama	9 (52.9)	7 (41.2)	1 (5.9)	0	0
Kahawatta	4 (44.4)	3 (33.4)	2 (22.2)	0	0
Average	**94 (44.1)**	**80 (37.6)**	**13 (6.1)**	**21 (9.9)**	**5 (2.3)**
Bluomendal	3 (9.4)	8 (25)	12 (37.5)	6 (18.7)	3 (9.4)
Madampitiya	2 (12.5)	5 (31.3)	4 (25)	1 (6.3)	4 (25)
Mahawaththa	2 (33.3)	2 (33.3)	2 (33.35)	0	0
Sammanthranapura	1 (10)	4 (40)	3 (30)	2 (20)	0
Mattakkuliya	1 (16.7)	2 (33.3)	2 (33.3)	1 (16.7)	0
Modara	1 (12.5)	2 (25)	1 (12.5)	3 (37.5)	1 (12.5)
Urban Average	**10 (12.8)**	**23 (29.5)**	**24 (30.8)**	**13 (16.7)**	**8 (10.3)**
Rural Average	**154 (47.1)**	**117 (35.8)**	**24 (7.3)**	**27 (8.3)**	**5 (1.5)**

Notes: **1**-Always helping, **2**- Helping most of the times, **3**-helping sometimes **4**-Rarely helping, **5**-Never helping

Source: Own HHs survey, 2018/2019

Table A-11: Trusting Local government authorities

GNDs	**1**	**2**	**3**	**4**	**5**
Kitulpe	2 (20)	5 (50)	1 (10)	2 (20)	0
Ihalagama	3 (18.8)	6 (37.4)	3 (18.8)	2 (12.5)	2 (12.5)
Galukagama	6 (23.1)	9 (34.6)	6 (23.1)	3 (11.5)	2 (7.7)
Theppanawa	2 (22.2)	3 (33.3)	3 (33.3)	1 (11.2)	0
Pahala Kuruwita	5 (45.4)	2 (18.2)	2 (18.2)	2 (18.2)	0
Miyanadeniya	6 (33.3)	5 (27.8)	2 (11.1)	4 (22.2)	1 (5.6)
Pahalagama	1 (12.5)	5 (62.5)	1 (12.5)	1 (12.5)	0
Ovitigama	5 (31.3)	5 (31.3)	4 (25)	2 (12.5)	0
Average	**30 (26.3)**	**40 (35.1)**	**22 (19.3)**	**17 (14.9)**	**5 (4.4)**
Raddella	7 (15.6)	18 (40)	12 (26.6)	3 (6.7)	5 (11.1)
Haldola	17 (40.5)	11 (26.2)	10 (23.8)	3 (7.1)	1 (2.4)
Karangoda	12 (31.5)	17 (44.7)	5 (13.2)	2 (5.3)	2 (5.3)
Dambuluwana	5 (18.5)	13 (48.1)	5 (18.5)	2 (7.5)	2 (7.4)
Amuwala	9 (25.7)	15 (42.90	5 (14.3)	4 (11.4)	2 (5.7)
Samangama	5 (29.4)	8 (47.1)	4 (23.5)	0	0
Kahawatta	2 (22.2)	4 (44.5)	1 (11.1)	2 (22.2)	0
Average	**57 (26.8)**	**86 (40.4)**	**42 (19.7)**	**16 (7.5)**	**12 (5.6)**
Bluomendal	1 (3.1)	7 (21.9)	10 (31.3)	6 (18.7)	8 (25)
Madampitiya	1 (6.3)	6 (37.5)	3 (18.8)	4 (25)	2 (12.5)
Mahawaththa	1 (16.7)	2 (33.2)	1 (16.7)	1 (16.7)	1 (16.7)
Sammanthranapura	2 (20)	2 (20)	4 (40)	2 (20)	0
Mattakkuliya	1 (16.7)	3 (50)	2 (33.3)	0	0
Modara	1 (12.5)	4 (50)	2 (25)	0	1 (12.5)
Urban Average	**7 (9)**	**24 (30.8)**	**20 (25.6)**	**15 (19.2)**	**12 (15.4)**
Rural Average	**87 (26.6)**	**126 (38.5)**	**64 (19.6)**	**33 (10.1)**	**17 (5.2)**

Notes: **1**-To a very great extent **2**- To a great extent, **3**-Neither great nor small extent **4**- To a small extent, **5**- To a very small extent

Source: Own HHs survey, 2018/2019

Table A-12: Trusting central government officials

GNDs	1	2	3	4	5
Kitulpe	1 (10)	6 (60)	1 (10)	2 (20)	0
Ihalagama	3 (18.8)	5 (31.1)	3 (18.8)	3 (18.8)	2 (12.4)
Galukagama	6 (23.1)	9 (34.6)	6 (23.1)	3 (11.5)	2 (7.7)
Theppanawa	1 (11.1)	4 (44.5)	3 (33.3)	1 (11.1)	0
Pahala Kuruwita	5 (45.4)	2 (18.2)	2 (18.2)	2 (18.2)	0
Miyanadeniya	4 (22.2)	6 (33.3)	3 (16.7)	4 (22.2)	1 (5.6)
Pahalagama	1 (12.5)	5 (62.5)	1 (12.5)	1 (12.5)	
Ovitigama	2 (12.5)	7 (43.7)	4 (25)	3 (18.8)	0
Average	**23 (20.2)**	**44 (38.6)**	**23 (20.2)**	**18 (15.8)**	**6 (5.3)**
Raddella	8 (17.8)	17 (37.7)	8 (17.8)	3 (6.7)	9 (20)
Haldola	3 (7.1)	21 (50)	10 (23.8)	6 (14.3)	2 (4.8)
Karangoda	2 (5.3)	20 (52.6)	9 (23.7)	4 (10.5)	3 (7.9)
Dambuluwana	2 (7.4)	16 (59.3)	1 (3.7)	2 (7.4)	6 (22.2)
Amuwala	9 (25.7)	14 (40)	3 (8.6)	2 (5.7)	7 (20)
Samangama	6 (35.3)	3 (17.6)	4 (23.6)	3 (17.6)	1 (5.9)
Kahawatta	2 (22.2)	3 (33.4)	1 (11.1)	1 (11.1)	2 (22.2)
Average	**32 (15)**	**94 (44.1)**	**36 (16.9)**	**21 (9.9)**	**30 (14.1)**
Bluomendal	1 (3.1)	5 (15.6)	7 (21.9)	5 (15.6)	14 (43.8)
Madampitiya	4 (25)	1 (6.3)	3 (18.8)	2 (12.5)	6 (37.5)
Mahawaththa	0	4 (66.7)	0	0	2 (33.3)
Sammanthranapura	2 (20)	4 (40)	1 (10)	3 (30)	0
Mattakkuliya	0	3 (50)	1 (16.7)	0	2 (33.3)
Modara	0	2 (25)	3 (37.5)	2 (25)	1 (12.5)
Urban Average	**5 (6.4)**	**17 (21.8)**	**18 (23.1)**	**10 (12.8)**	**28 (35.9)**
Rural Average	**55 (16.8)**	**138 (42.3)**	**59 (18)**	**39 (11.9)**	**36 (11)**

Notes: 1-To a very great extent 2- To a great extent, 3-Neither great nor small extent 4- To a small extent, 5- To a very small extent

Source: Own HHs survey, 2018/2019

Appendixes 3: Collective action and cooperation

Statistics of collective actions

Table A-13/1: Have you worked with others/rural

N	Valid	327
	Missing	0
Mean		1.02

Table A-13/2: **Have you worked with others**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	320	97.9	97.9	97.9
	No	7	2.1	2.1	100.0
	Total	327	100.0	100.0	

Table A-13/3: Have you worked with others/urban

N	Valid	78
	Missing	0
Mean		1.42

Table A-13/4: **Have you worked with others/ urban**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	45	57.7	57.7	57.7
	No	33	42.3	42.3	100.0
	Total	78	100.0	100.0	

Appendixes 4: Information and communication

Table A-14/1 : How often listening radios/Kuruwita DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Every day	48	42.1	42.1	42.1
	A few times a week	8	7.0	7.0	49.1
	Once a week	2	1.8	1.8	50.9
	Never	56	49.1	49.1	100.0
	Total	114	100.0	100.0	

Table A-14/2: How often watching Televisions / Kuruwita DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Every day	99	86.8	86.8	86.8
	A few times a week	3	2.6	2.6	89.5
	Once a week	1	.9	.9	90.4
	Never	11	9.6	9.6	100.0
	Total	114	100.0	100.0	

Table A-14/3: Source of information /Kuruwita DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Relatives, friends and neighbors	61	53.5	54.5	54.5
	GND office	27	23.7	24.1	78.6
	Local/National Newspapers	5	4.4	4.5	83.0
	Radio	4	3.5	3.6	86.6
	Television	15	13.2	13.4	100.0
	Total	112	98.2	100.0	
Missing	System	2	1.8		
Total		114	100.0		

Table A-14/4: How often listening radios /Elapatha DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Every day	84	39.4	39.4	39.4
	A few times a week	27	12.7	12.7	52.1
	Once a week	1	.5	.5	52.6
	Less than once a week	1	.5	.5	53.1
	Never	100	46.9	46.9	100.0
	Total	213	100.0	100.0	

Table A-14/5: How often watching Televisions / Elapatha DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Every day	179	84.0	84.0	84.0
	A few times a week	6	2.8	2.8	86.9
	Less than once a week	1	.5	.5	87.3
	Never	26	12.2	12.2	99.5
	6	1	.5	.5	100.0
	Total	213	100.0	100.0	

Table A-14/6: Source of information /Elapatha DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Relatives, friends and neighbors	57	26.8	27.9	27.9
	GND office	100	46.9	49.0	77.0
	Local/National Newspapers	5	2.3	2.5	79.4
	Radio	12	5.6	5.9	85.3
	Television	30	14.1	14.7	100.0
	Total	204	95.8	100.0	
Missing	System	9	4.2		
Total		213	100.0		

Table A-14/7: How often listening radios / Colombo DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Every day	47	60.3	60.3	60.3
	A few times a week	6	7.7	7.7	67.9
	Less than once a week	1	1.3	1.3	69.2
	Never	24	30.8	30.8	100.0
	Total	78	100.0	100.0	

Table A-14/8: How often watching Televisions/ Colombo DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Every day	13	16.7	16.7	16.7
	A few times a week	2	2.6	2.6	19.2
	Less than once a week	1	1.3	1.3	20.5
	Never	62	79.5	79.5	100.0
	Total	78	100.0	100.0	

Table A-14/9 :Source of information 3 /Colombo DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Relatives, friends and neighbors	38	48.7	49.4	49.4
	GND office	17	21.8	22.1	71.4
	Local/National Newspapers	16	20.5	20.8	92.2
	Radio	2	2.6	2.6	94.8
	Television	4	5.1	5.2	100.0
	Total	77	98.7	100.0	
Missing	System	1	1.3		
Total		78	100.0		

Appendixes 5: Social cohesion and inclusion

Table A-15/1 : Diversities of villagers / Kuruwita DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	To a great extent	113	99.1	99.1	99.1
	To a small extent	1	.9	.9	100.0
	Total	114	100.0	100.0	

Table A-15/2 : Diversities of villagers /Elapatha DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	To a very great extent	10	4.7	4.7	4.7
	To a great extent	193	90.6	90.6	95.3
	Neither great nor small extent	10	4.7	4.7	100.0
	Total	213	100.0	100.0	

Table A-15/3 : Diversities of villagers / Colombo DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	To a very great extent	2	2.6	2.6	2.6
	To a great extent	73	93.6	93.6	96.2
	Neither great nor small extent	3	3.8	3.8	100.0
	Total	78	100.0	100.0	

Table A-15/4 : Do diversities cause problems? /Kuruwita DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	10	8.8	8.8	8.8
	No	104	91.2	91.2	100.0
	Total	114	100.0	100.0	

Table A-15/5: Do diversities cause problems?/ Elapatha

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	15	7.0	7.0	7.0
	No	198	93.0	93.0	100.0
	Total	213	100.0	100.0	

Table A-15/6 : Do diversities cause problems?/ Colombo

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	24	30.8	30.8	30.8
	No	54	69.2	69.2	100.0
	Total	78	100.0	100.0	

Table A-15/7 :Reason often cause problem 1 / Kuruwita DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Differences in landholding	3	2.6	2.6	2.6
	Differences between long-term and recent residents	46	40.4	40.4	43.0
	Differences in political party affiliations	65	57.0	57.0	100.0
	Total	114	100.0	100.0	

Table A-15/8 :Reason often cause problem 2 / Kuruwita

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Differences in landholding	53	46.5	46.5	46.5
	Differences in wealth/material possessions	1	.9	.9	47.4
	Differences between long-term and recent residents	11	9.6	9.6	57.0
	Differences in political party affiliations	49	43.0	43.0	100.0
	Total	114	100.0	100.0	

Table A-15/9: Reason often cause problem 1/ Elapatha DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Differences in education	1	.5	.5	.5
	Differences in landholding	80	37.6	37.6	38.0
	Differences between long-term and recent residents	62	29.1	29.1	67.1
	Differences in political party affiliations	69	32.4	32.4	99.5
	Other differences	1	.5	.5	100.0
	Total	213	100.0	100.0	

Table A-15/10: Reason often cause problem 2 / Elapatha

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Differences in landholding	55	25.8	25.8	25.8
	Differences in wealth/material possessions	1	.5	.5	26.3
	Differences between long-term and recent residents	19	8.9	8.9	35.2
	Differences in political party affiliations	138	64.8	64.8	100.0
	Total	213	100.0	100.0	

Table A-15/11: Reason often cause problem 1 / Colombo

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Differences in education	1	1.3	1.3	1.3
	Differences in landholding	63	80.8	80.8	82.1
	Differences between long-term and recent residents	10	12.8	12.8	94.9
	Differences in political party affiliations	4	5.1	5.1	100.0
	Total	78	100.0	100.0	

Table A-15/12:Reason often cause problem 2/ Colombo DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Differences in landholding	4	5.1	5.2	5.2
	Differences between long-term and recent residents	46	59.0	59.7	64.9
	Differences in political party affiliations	27	34.6	35.1	100.0
	Total	77	98.7	100.0	
Missing	System	1	1.3		
Total		78	100.0		

Table A-15/13 How many times got together

N	Valid	114
	Missing	0
Mean		3.15

Table A-15/14 - How many times got together /Kuruwita DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	.9	.9	.9
	1	10	8.8	8.8	9.6
	2	7	6.1	6.1	15.8
	3	56	49.1	49.1	64.9
	4	34	29.8	29.8	94.7
	5	5	4.4	4.4	99.1
	6	1	.9	.9	100.0
	Total	114	100.0	100.0	

Table A -15/15:How many times got together /Elapatha DSD

	Valid	213
	Missing	0
Mean		2.78

Table A -15/16- How many times got together/ Elapatha

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	17	8.0	8.0	8.0
	2	59	27.7	27.7	35.7
	3	104	48.8	48.8	84.5
	4	21	9.9	9.9	94.4
	5	10	4.7	4.7	99.1
	6	2	.9	.9	100.0
	Total	213	100.0	100.0	

Table A-15/17**:**How many times got together / Colombo DSD

N	Valid	78
	Missing	0
Mean		1.65

Table A-15/18- How many times got together/ Colombo DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	37	47.4	47.4	47.4
	2	31	39.7	39.7	87.2
	3	10	12.8	12.8	100.0
	Total	78	100.0	100.0	

Appendix 6- Empowering people and political actions

Table A-16/1 : How you impact to change village /Kuruwita

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A big impact	13	11.4	11.4	11.4
	A small impact	64	56.1	56.1	67.5
	No impact	36	31.6	31.6	99.1
	4	1	.9	.9	100.0
	Total	114	100.0	100.0	

Table A-16/2 : How you jointly acts for common goals / Kuruwita

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	110	96.5	96.5	96.5
	A few times	3	2.6	2.6	99.1
	No impact	1	.9	.9	100.0
	Total	114	100.0	100.0	

Table A-16/3 : Were they successful / Kuruwita

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, all were successful	4	3.5	3.5	3.5
	Most were unsuccessful	2	1.8	1.8	5.3
	None were successful	108	94.7	94.7	100.0
	Total	114	100.0	100.0	

Table A-16/4: Did you vote on last election /Kuruwita

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	111	97.4	97.4	97.4
	No	3	2.6	2.6	100.0
	Total	114	100.0	100.0	

Table A-16/5: How you impact to change village / Elapatha DSD Q.66/6/3.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A big impact	70	32.9	32.9	32.9
	A small impact	90	42.3	42.3	75.1
	No impact	52	24.4	24.4	99.5
	4	1	.5	.5	100.0
	Total	213	100.0	100.0	

Table A-16/6: How you jointly acts for common goals (q.66/6/4) / Elapatha DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	186	87.3	87.3	87.3
	Once	5	2.3	2.3	89.7
	A few times	22	10.3	10.3	100.0
	Total	213	100.0	100.0	

Table A-16/7: Were they successful /Elapatha DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, all were successful	18	8.5	8.5	8.5
	Most were successful	5	2.3	2.3	10.8
	Most were unsuccessful	1	.5	.5	11.3
	None were successful	189	88.7	88.7	100.0
	Total	213	100.0	100.0	

Table A-16/8: Did you vote on last election / Elapatha DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	211	99.1	99.1	99.1
	No	2	.9	.9	100.0
	Total	213	100.0	100.0	

Table A-16/9 : How you impact to change village / Colombo DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A big impact	4	5.1	5.1	5.1
	A small impact	21	26.9	26.9	32.1
	No impact	52	66.7	66.7	98.7
	4	1	1.3	1.3	100.0
	Total	78	100.0	100.0	

Table A-16/10: How you jointly acts for common goals / Colombo DSD Q.66/6/3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	74	94.9	94.9	94.9
	Once	1	1.3	1.3	96.2
	A few times	1	1.3	1.3	97.4
	No impact	2	2.6	2.6	100.0
	Total	78	100.0	100.0	

Table A-16/11: Were they successful / Colombo DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, all were successful	2	2.6	2.6	2.6
	None were successful	76	97.4	97.4	100.0
	Total	78	100.0	100.0	

Table A-16/12: Did you vote on last election / Colombo DSD

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	76	97.4	97.4	97.4
	No	2	2.6	2.6	100.0
	Total	78	100.0	100.0	

Appendix 7: Exposure, sensitivity and adaptive capacity

Table A-17: Exposure, sensitivity and adaptive capacity

GNDs	**Exposure**	**Sensitivity**	**AC**
Kitulpe	0.64	0.42	0.61
Ihalagama	0.49	0.30	0.60
Galukagama	0.46	0.34	0.60
Theppanawa	0.72	0.36	0.63
Pahala Kuruwita	0.53	0.30	0.63
Miyanadeniya	0.69	0.36	0.58
Pahalagama	0.73	0.27	0.66
Ovitigama	0.69	0.33	0.58
Average	**0.62**	**0.34**	**0.61**
Raddella	0.81	0.37	0.59
Haldola	0.72	0.34	0.55
Karangoda	0.69	0.30	0.53
Dambuluwana	0.70	0.36	0.58
Amuwala	0.70	0.30	0.55
Samangama	0.63	0.28	0.63
Kahawatta	0.66	0.36	0.55
Average	**0.70**	**0.33**	**0.57**
Bluomendal	0.31	0.41	0.42
Madampitiya	0.55	0.39	0.48
Mahawaththa	0.51	0.41	0.52
Sammanthranapura	0.43	0.42	0.52
Mattakkuliya	0.50	0.38	0.63
Modara	0.58	0.43	0.50
Urban Average	**0.48**	**0.41**	**0.51**
Rural Average	**0.66**	**0.33**	**0.59**

Source : Own calculation, 2019.

Appendix 8:

Table A-18: Adjacency matrix of Ovitigama GND at after flood inundation phase (e.g. who helped whom at after flooding event)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	OV 1	OV 2	OV 3	OV 4	OV 5	OV 6	OV 7	OV 8	OV 9	OV 10	OV 11	OV 12	OV 13	OV 14	OV 15	OV 16	OV 17	OV 18	OV 19	OV 20	OV 21	OV 22	OV 23	OV 24	OV 25	OV 26	OV 27	OV 28	OV 29	OV 30	OV 31	OV 32	OV 33
1	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3	1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	9	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	14	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	16	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	OV1	1	1	0	1	1	0	1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	OV2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	OV3	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	OV4	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	OV5	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	OV6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	OV7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	OV8	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	OV9	0	0	1	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	OV10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	OV11	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	OV12	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	OV13	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	OV14	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	OV15	1	0	1	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	OV16	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	OV17	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

| | | |

Appendix 9

Questionnaire of the Study

Questionnaire Serial No.		Contact Number(s) of household	
Date of carried out			
Done by			
Level of education (Undergrads/degree)			
Whether	Complete		If incomplete –reason(s)
	Incomplete		
Checked by			

Dear Parents, Friends, and All,

I am Ananda Karunarathne, a faculty member, at the Department of Geography, University of Colombo. My residence place is No. 134/37A, Nadukaradeniya, Paradise, Kuruwita. I am doing my PhD research work on how you receive helps from others and helping each other and your socio-economic networks (simply the nature of relationships of each other) in the flooding events. I would like to collect some of data about your households, your lives and experiences at before, during, and after the flooding events. All the information collecting by this research will be considered as highly private and confidential in order to secure your privacies. I highly appreciate your kind participation and cooperation (only if you are agree to answer/with your consent) during the interview.

Thanks You Very Much.

Basic Information about the admin area

DSD Name			
GND name and number			
Village			
GND-officer's name and contact number			
Sector *(circle the appropriate number)*	1.Urban	2. Rural	3. Estate
Note book record number			

1. Basics information about Household

<table>
<tr><td rowspan="3">GPS – Location and the code number of household</td><td>Code:</td><td rowspan="5">6. Built material (circle the relevant number)</td><td>6.1 Roof</td><td>1. Brick, 2.Asbestos, 3. Aluminum sheet, 4. Leaves, 5. Concrete, 6. Other.</td></tr>
<tr><td>X-</td><td rowspan="2">6.2 Wall</td><td rowspan="2">1. Bricks 2. Cement 3. Clay 4. Other</td></tr>
<tr><td>Y-</td></tr>
<tr><td rowspan="2">1. Elevation of the household in meters (from MSL)</td><td rowspan="2"></td><td rowspan="3">6.3 Floor</td><td rowspan="3">1. Cement 2. Tiles 3. Clay 4. Other</td></tr>
<tr><td rowspan="2">2. Distance to nearest river or tributary and its name</td></tr>
<tr><td></td></tr>
<tr><td>3. Owner of House</td><td></td><td colspan="2" rowspan="2">7. 1 Number of rooms
7. 2 Size of house (sq. feet)</td><td rowspan="2"></td></tr>
<tr><td rowspan="2">4.Year of built and condition*</td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td>5. Number of residence living</td><td></td><td colspan="2">8. Number of stores</td><td></td></tr>
<tr><td colspan="5">Address of Household:</td></tr>
</table>

* **4.1** Permanent; **4.2** Under construction; **4.3** Temporary/huts

2.1 Basic Facilities of household

9. Communication equipment		**10.** Drinking water sources		**11.** Toilet facilities		**12.** Methods of Lighting		**13.** Cooking fuel		**14.** Solid waste disposal	
1- Mobile telephone.		1- Well 2 -Pipe line		1-Water seal		1-Electricity		1-Firewood		1-Collecting by locality	
2- Fixed line		3-Tube well		2-Direct fit		2-Kerosone		2-Kerosone		2-Composting	
3- Radio		4- River / tributary		3. No toilet		4-Solar power		3-Gas		3-Disposal to near place	
4- Television		5- Bottled water		4- Other		5. No way; 6-Other		4-Elctricity		4-Other	
5-No; 6 - Other		7. No; 7- Other						5-Other			

2.2 Resources / assets (owned) 15. 1 car; 2van; 3 three-wheeler; 4 bike; 5 land master; 6 no assets; 7 other (tea or other plantation)

3.1 Basics Information about residence

Name	**16.1** Age	**16.2** Gender (1-male; 2-female; 3- other)	**17.** Relationship to the head of the household*	**18.** Marital stages (1-married;2-single; 3-divorced; 4. Separated; 5. or widowed)	**19.**Religion **	**20.** Place of Birth (if in difference place, pls. go to q.3.2
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						

*: 1. Head, 2. Husband, 3. Wife, 4. Son, 5. Daughter, 6. Father, 7. Mother, 8. G. Mother, 9. G. Father, 10. Son-in-law, 11. Daughter-in-law, 12. Other. (indicate)
**1. Buddhist, 2. Hindu, 3. Roman Catholic, 4. Other

3.2 Internal migration status

21. Years of residence in this place	**22.**Years of residence in previous place	**23.**Reasons for migrating to this place
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

Reasons:1. Marriage, 2. Education, 3. Employment, 4. Displaced 5. Health issues, 6. Other

3.3 * 1-Government; 2-Semi-gov.; 3-Private; 4-Employer; 5-No employment, 6- Other

** 1-Teaching; 2-Excutive; 3-Clarical; 4-Military Services; 5- Labourer ; 6-Other

*** 1-Student; 2-Household work; 3-Pensoner; 4-Old-aged / unable to work; 5-Others

**** 1-Agriculture; 2-Running self-business; 3-Contactor; 4-Other

***** 1) Less than 15,000 2) 16,000 - 30,000, 3) 31,000 - 41,000, 4) 41,000 -60,000, 5). >61,000 LKR.(Sri Lankan Rupees).

(Please put the exact amount with the code)

3.3 Income and Expenditure

24. Employment status *		**25.** Occupation **	**26.** Non-economic activities ***	**27.** Other economic activities ****	**28.**Household expenditure	**29.1** Amount per month (in Rs)
1.					1-Food	
2.					2-Education	
3.					3-Health	
4.					4-Other needs	
5.					Total	
6.					**29.2** Monthly income of the family *****	
7.						
8.						

3.4 Educational Information

30. Highest education attained*		**31.** Professional Education**	**32.** Abilities***	**32.1** Sinhalese (1-yes; 2-no)	**32.2** English (1-yes; 2-no)	**32.3** Tamil (1-yes; 2- no)	**32.4** Ability to use computers (1-yes; 2-no)
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							

* 1) Never attend; 2) Grade 1 to 5; 3) Grade 6 to 10; 4) O/L; 5- A/L; 6) Degree; 7) PGD; 8) PG; 9) PhD

** 1-Technical college / College of Technology; 2-National vocational qualification (NVQ); 3- Others; 4 – None

*** 1-Speaking; 2-Imposible to speak; 3-Writing; 4- impossible to write; 5- Reading; 6- impossible to read

4.1 Healthcare Information (Physical-mental difficulties)

33.difficulty */illness (pls. mention)		**33.1** Speaking *	**33.2** Seeing *	**33.3** Hearing *	**33.4** Walking *	**33.5** Cognition (memorizing cum concentrating) *	**33.6** Doing Day-today things *	**33.7** Other disability
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								

34.1 Numbers of days visiting for medical officers

	Number of days			Reason(s)	**35.** Medical cost (Rs)		
	Per week	Per month	Per year		Per week	Per month	Per year
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							

*1-No difficulty; 2-Difficult; 3-Extremely difficult

34. 2 How you obtain information for making health decisions before flooding ☐

34. 3 During flooding ☐ **34. 4** After flooding ☐

1. from relatives, 2. From neighbors, 3. From government officers (e.g GN officers, Midwives etc.), 4. Other

34. 5 How you rate the influence and advices of others for your health decisions ☐

1. Strongly influence, 2. Somewhat influence, 3. Neutral, 4. Not influence, 5. I made myself

34. 6 Did you guide and help villagers to find health information when they need? 1) Yes, 2) No. ☐

34. 7 How you rate your influence and helps for others on their health needs and decisions? ☐

1. Strongly influence, 2. Somewhat influence, 3. Neutral, 4. Not influence, 5. They do their selves

4.2 Healthcare Information (Healthcare Facilities)

36. Nearest health facility to household		**37.**Distance (in m/km)	**38.** Your satisfaction on existing healthcare facilities *
1-Government hospital			
2-Government MOH office			
3-Private hospital			
4-Dispensary			
5-Other			

* (1)-strongly satisfied; (2)-Satisfied; (3) Neutral; (4)-Unsatisfied; (5)-Strongly unsatisfied.

5. Infrastructure Facilities of village / town/ city

Status	**39.** Road facilities			**40.**Elect ricity	**41.**Transportation services		**42.**Pipe Water	**43.**Comm unity centers	**44.** School	
	Tar	Concrete	Gravel		Public	Private			Public	Private
1-Yes 2-No										
45. Your overall satisfaction about available infrastructure facilities										
(1)-Strongly Satisfy; (2)-Satisfy; (3)-Neutral; (4)-Dissatisfy; (5)-Strongly unsatisfied										
Nb- Personal observations should be noted under the relevant 'note book' record										

6. 1 Nature of Hazards (46.1)

1- Inundated; 2- Isolated (no access to household / village); 3- Both / (circle the appropriate)

6.2 Household Flood inundation records and Information

46.2 Flood inundation (since 2015)	**47.** Heights of inundation (since 2015) *		**48.** How many times per year (Specify the months)			**49.** How many days remained	**50.**Damages (in numbers with brief descriptions)							
							50.1-Lives (deaths)		**50.2**-Furniture & goods		**50.3**- vehicles		**50.4**-Other	
1-Yes; 2- No							1-yes; 2-no		1-yes; 2-no		1-yes; 2-no		1-yes; 2-no	
	2015		2015											
	2016		2016											
	2017		2017											

*-note the years and heights (in feet) inundated

7. Flood evacuation plans and aftermaths (51.1) **53. 1** How many days stayed outside: **53.2** How far from your home to stayed place:
Did your family evacuate?; 1-Yes; 2-No (if no, please mention the reason(s);……

During the flood inundation					
51.2 How your family knew about flooding (from whom)	**52.** How did your family evacuated	**53.3**Where your family stayed	**54.1**Received Food and basics needs	**54.2** What kinds of things received	**55.**Health care facilities
1- Self investigation	1-Alone	1-Government Schools	1-Friends	1-foods	1-Government
2- Family members	2-With family members or Relatives	2-Buddhist temple or other Religious places	2-Neibours	2- cloths (specially necessary cloths for ladies)	2-Vulentier MO groups
3-Friends	3- With friends	3-Cummunity centers	3-Family members/relative	3- Drinking water	3-Army forces
4- Relatives	4-With government forces	4-Temporary camps	4-Government	4- sanitation facilities	4-Helpers
5- Government announcements	5-With other volunteers	5-Friends' places	5-Volunteers	5- Basic medicines	5-Other ways
		6-Relatives'place			
6-Others	6-Any other ways	7-Other way	6- Self or Other ways	6- Other 7- Nothing received	6- Not provided

8 Collaboration & consequences after the flood inundations

After the floods				
56.1 Who helped for cleaning up household	**56.2** Who helped to clean public places */environment	**57.**Who made financial assistant	**58.**Who gave foods and other basics needs after moved in	**59.**Water-borne and Vector-borne diseases after the floods
1-Nieghbours	1-Nieghbours	1-Government	1-Government	1-Dengue
2-Friends	2-Friends	2-Public collections	2-Public collections	2-Cholera
3-Family members	3-Family members	3-Relatives	3-Friends	3-Leptospirosis
4- Relatives	4- Relatives	4-Family members	4-Family members	4-Hepatitis A
5-Army forces	5-Army forces	5-Friends	5- Relatives	5-Yellow fever
6- Volunteers or others	6- Volunteers or Others	6- Volunteers or others	6- Volunteers or others	6-Others
7- No one helped	7- No one helped	7 – No one assisted	7- No one gave	7 –No effects/ disease

* Wells, toilets, any other public places

9. Your overall feelings and rates, about reciprocal supports; before flood inundation (60)

About followings	Your feelings: (1)-Strongly Agree, (2)-Agree, (3)-Neutral, (4)-Disagree, (5)- Strongly disagree
60.1 - I received all the necessary information before the flooding	
60.2 -I received very good helps by friends	
60.3 - I received very good helps by neighbors	
60.4 - I received very good helps by the Government	
60.5 - I received very good helps by volunteers	
60.6 - Local authorities announced necessary information on right time	
60.7 - No one helped me	
60.8 - I did everything myself	
60.9 – I have strong trust about others on readying for flooding	
60.10 - I also helped my neighbors and friends to move out things before floods	
60.11-We collaborated with other to overcome our difficulties	

10. Your overall feelings and rates, about reciprocal supports; during flood inundation (61)

About followings	Your feelings: (1)-Strongly Agree, (2)-Agree, (3)-Neutral, (4)-Disagree, (5)-Strongly disagree
61.1- I received all the necessary information on evacuation	
61.2- I received very good helps by friends	
61.3- I received very good helps by neighbors	
61.4- I received very good helps by the Government and forces	
61.5- I received very good helps by volunteers	
61.6- Local authorities announced necessary information on right time	
61.7- No one helped me	
61.8- I did everything myself	
61.9- I did feel run out food, water, and other basics need during the floods	
61.10- I received all the basics needs during the floods	
61.11 – I have strong trust about others on evacuation flooding	
61.12- My overall rate about helps rendered by other during the floods	
61.13- I also helped my neighbors and friends to evacuate during floods	
61.14- We collaborated with other to overcome our difficulties	
61.15 - We had alternative access roads to evacuate during the floods	

11. Your overall feelings and rates, about reciprocal supports; after the flood inundation (62)

About followings	Your feelings: (1)-Strongly Agree, (2)-Agree, (3)-Neutral, (4)-Disagree, (5)-Strongly disagree
62.1 - I received all the necessary information after the flooding	
62.2 - I received very good helps by friends	
62.3 - I received very good helps by neighbors	
62.4 - I received very good helps by the Government and forces	
62.5 - I received very good helps by volunteers	
62.6 - Local authorities announced necessary information on right time	
62.7 - No one helped me	
62.8 - I did everything myself	
62.9 - I did feel run out food, water, and other basics need after the floods	
62.10 – I am feeling, I have lost everything after flooding	
62.11- My overall rate about helps rendered by other after the floods	
62.12 - I also helped my neighbors and friends to move in after floods	
62.13 - We collaborated with other to overcome our difficulties	

12. Socio-economic networks connections / flows: Before flood inundation (63.1)

Persons *	A	B	C	D	E	F	G	H	I	J	K	L	Name(s) & contact(s) (use separate records in notebook for contacts information)	Relation to you (Y)	Place of reside	How long you known him/her (yrs)	Helped you received (Z)
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
63.2													← Crosschecked and confirmed the helps received, 1-Yes, 2-No				

(Y): 1-friend, 2- neighbor, 3- family relation /relatives , 4- GNO / government officer, 5- volunteer helper, 6- forces member, 7- others

(Z): 1- information, 2- evacuation /lifesaving, 3-moved out necessary things from house, 4- foods, 5- other goods, 6- money, 7- provision of housing facility for staying, 8- other.

* the number of persons in his/her networks (considered only the active connections, before, during, and after the flood inundation events), possible to be changed depends upon the cases.

13. Socio-economic networks connections / flows: During the flood inundation (64.1)

Persons *	A	B	C	D	E	F	G	H	I	J	K	L	Name(s) & contact(s) (use separate records in notebook for contacts information)	Relation to you (Y)	Place of reside	How long you known him/her (yrs)	Helped you received (Z)
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
64.2													← Crosschecked and confirmed the helps received, 1-Yes, 2-No				

(Y): 1-friend, 2- neighbor, 3- family relation / relatives, 4- GNO / government officer, 5- volunteer helper, 6- forces member, 7- others

(Z): 1- information, 2- evacuation, 3-moved out necessary things from house, 4- foods, 5- health care, 6- money, 7- provision of housing facility for staying, 8- Other (specify)

* the number of persons in his/her networks (considered only the active connections, before, during, and after the flood inundation events), possible to be changed depends upon the cases.

14. Socio-economic networks connections / flows: After flood inundation (65.1)

Persons *	A	B	C	D	E	F	G	H	I	J	K	L	Name(s) & contact(s) (use separate records in notebook for contacts information)	Relation to you (Y)	Place of reside	How long you known him/her (yrs)	Helped you received (Z)
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
65.2													← Crosschecked and confirmed the helps received, 1-Yes, 2-No				

(Y): 1-friend, 2- neighbor, 3- family relation / relatives , 4- GNO / government officer, 5- volunteer helper, 6- forces member, 7- others

(Z): 1- advice, 2- emotional helps, 3-cleaning and moved in every things to house, 4- foods and other goods, 5- health care, 6- money, 7- other; nb. Separate records need to be maintained in the field note book, particularly in order to identify the "hubs" and "egos" of above networks process (before, during, and after the flood inundation)

* the number of persons in his/her networks (considered only the active connections, before, during, and after the flood inundation events), possible to be changed depends upon the cases.

15. How Social Capital Works of your community in day today-life (66)

15.1 Village Associations and Groups (66.1): Do you have any membership of village associations and groups : 1. Yes, 2. No (household)

Household Member (when more than one memberships, use the blank rows)	**66.1.1** Name (s) of Groups or Organization	**66.1.2** What is the most important group to your household?*	**66.1.3** How do you participate in Group's decision making? **	**66.1.4** What are the benefits you are receiving?	**66.1.5** How many *close* friends do you have in the group?
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					

** 1. Leader, 2.Very active, 3. Somewhat active, 4. No participation in decision making

* **66.1.6** Thinking about the members of this group, are most of them same in…1 Yes, 2 No

A. Religion	
B. Gender	
C. Ethnic or linguistic background/ race/caste/other	

66.1.7 Do members mostly have the same…1 Yes, 2 No

A. Occupation	
B. Educational background or level	

66.1.8 Does this group work with or interact with *groups outside* the village/neighborhood? ☐
1. No; 2. Yes, occasionally; 3. Yes, frequently
66.1.9 If you suddenly needed to borrow a small amount of money, possibility to have this money? ☐
1. Definitely, 2. Probably, 3. Unsure, 4. Probably not, 5. Definitely not

15.2 Trust and Solidarity (66.2):
66.2.1 How can you trust of your community (particularly in flooding events)?

About Followings	**Your feelings?***
66.2.1.1 Most of the people who live in this village /your neighborhood can be trusted?	
66.2.1.2 Most people in your village/neighborhood are willing to help if you need helps	
66.2.1.3 People generally do not trust each other in matters of lending and borrowing money or helping each other	
66.2.1.4 Do you help each other in this village when they need?	

* (1)-Strongly Agree, (2)-Agree, (3)-Neutral, (4)-Disagree, (5)- Strongly disagree

66.2.2 How well do people in your village/neighborhood help each other in the flooding situation? (general feeling rather than q. 60, 61, 62).
(1) Always helping, (2) Helping most of the time, (3) Helping sometimes, (4) Rarely helping, (5) Never helping ☐
66.2.3 How much do you trust…. A - Local government officials ☐ , B- Central government officials ☐ 1) To a very great extent, 2) To a great extent, 3) Neither great nor small extent, 4) To a small extent, 5) To a very small extent.

15.3 Collective Action and Cooperation (66.3):
66.3.1 In the past 12 months, have you worked with others in your village/ neighborhood to do something for the benefit of the community? 1. Yes; 2. No. (please circle the appropriate)
66.3.2 What were the three main such activities in the past 12 months? Was participation in these voluntary or required?

Activity	voluntary	required
1.		
2.		
3.		

66.3.3 How likely is it that people who do not participate in community activities like flooding events will be criticized or sanctioned? 1.Very likely; 2.Somewhat likely; 3.Neither likely nor unlikely; 4.Somewhat unlikely; 5. Very unlikely. (please circle the appropriate)

66.3.4 If there was a water supply problem in this community, how likely is it that people will cooperate to try to solve the problem? 1.Very likely; 2.Somewhat likely; 3.Neither likely nor unlikely; 4.Somewhat unlikely; 5. Very unlikely. (please circle the appropriate)

15.4 Information and Communication (66.4):

66.4.1 In the flooding situations, how many times have you made or received a phone call? (practically, it may difficult to recall the exact numbers/ please note generally the average)

Before Flooding	
During Flooding	
After Flooding	

66.4.2 How often do you listen to the radio?
(1) Every day, (2) A few times a week, (3) Once a week, (4) Less than once a week, (5) Never ☐

66.4.3 How often do you watch television?
(1) Every day, (2) A few times a week, (3) Once a week, (4) Less than once a week, (5) Never ☐

66.4.4 What are the three most important sources of information about day-to-day information?
(1) Relatives, friends and neighbors, (2) GND office, (3) Local/National Newspapers, (4) Radio, (5) Television, (6) Internet (please put the numbers)

15.5 Social Cohesion and Inclusion (66.5):

66.5.1 There are often differences in characteristics between people living in the same village/neighborhood (For example, differences in wealth, income, social status, ethnic or linguistic background/race/caste/tribe). There can also be differences in religious or political beliefs, or there can be differences due to age or sex. To what extent do any such differences characterize your village/neighborhood? ☐
(1) To a very great extent, (2) To a great extent, (3) Neither great nor small extent, (4) To a small extent, (5) To a very small extent

66.5.2 Do any of these differences cause problems? (1) Yes, (2) No. ☐

66.5.3 Which two differences most often cause problems? ☐☐

(1) Differences in education, (2) Differences in landholding, (3) Differences in wealth/material possessions, (4) Differences in social status, (5) Differences between men and women, (6) Differences between younger and older generations, (7) Differences between long-term and recent residents, (8) Differences in political party affiliations, (9) Differences in religious beliefs, (10) Differences in ethnic or linguistic background/race/caste/tribe, (11) Other differences

66.5.4 Have these problems ever led to violence? (1) Yes, (2) No. ☐

66.5.5 How many times in the past month have you got together with people to have food or drinks, either in their home or in a public place? ☐

66.5.6 [if not zero] were any of these people…. 1 Yes; 2 No.

A. Of different ethnic or linguistic background/ race/caste/tribe?	
B. Of different economic status?	
C. Of different social status?	
D. Of different religious groups?	

66.5.7 In general, how safe from crime and violence do you feel when you are alone at home?

(1) Very safe, (2) Moderately safe, (3) Neither safe nor unsafe, (4) Moderately unsafe, (5) Very unsafe ☐

15.6 Empowerment and Political Action (66.6):

66.6.1 In general, how happy do you consider yourself to be? ☐

(1) Very happy, (2) Moderately happy, (3) Neither happy nor unhappy, (4) Moderately unhappy, (5) Very unhappy

66.6.2 Do you feel that you have the power to make important decisions that change the course of your life? ☐

(1) Totally unable to change life, (2) Mostly unable to change life, (3) Neither able nor unable, (4) Mostly able to change life, (5) Totally able to change life

66.6.3 Overall, how much impact do you think you have in making this village/neighborhood a better place to live? (1) A big impact, (2) A small impact, (3) No impact ☐

66.6.4 In the flood disaster events, how often have people in this village/neighborhood got together to jointly petition government officials or political leaders for something benefiting the community? ☐

(1) Never, (2) Once, (3) A few times (<5), (4) Many times (>5)

66.6.5 Were any of these petitions successful? (1) Yes, all were successful, (2) Most were successful, (3) Most were unsuccessful, (4) None were successful ☐

66.6.6 Lots of people find it difficult to get out and vote. Did you vote on the last Pradesiya Saba/Provincial/ Parliament/ presidential election? 1 Yes, 2 No. ☐

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